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DESIGN MEMORANDUM NO.1

REDBANK AND FANCHER CREEKS

CALIFORNIA

GENERAL DESIGN MEMORANDUM

US Army Corps of Engineers

Sacramento District

FEBRUARY 1986

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REDBANK AND FANCHER CREEKS
CALIFORNIA

GENERAL DESIGN MEMORANDUM

FEBRUARY 1986

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT
SACRAMENTO, CALIFORNIA

REDBANK AND FANCHER CREEKS
CALIFORNIA

DESIGN MEMORANDOMS

Date	DM No.	Title	Scheduled Submittal Date	Date of Approval
February 1986	1	General Design Memorandum	February 1986	
	2	Big Dry Creek Dam FDM	September 1986	
	3	Fancher Creek Dam FDM	September 1986	
	4	Detention Basins FDM	September 1986	
	5	Big Dry Creek Dam Geology DM	September 1986	
	6	Fancher Creek Dam Geology DM	September 1986	
	7	Detention Basins Geology DM	September 1986	
	8	Concrete Materials DM	September 1986	

SPDPD-S

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
650 CAPITOL MALL
SACRAMENTO, CALIFORNIA 95814

REPLY TO
ATTENTION OF

SPKED-D

18 February 1986

SUBJECT: Redbank and Fancher Creeks, California, Final General Design Memorandum

Commander, South Pacific Division
ATTN: SPDED-PC

1. References:

a. SPDED-TC 2 December 1981 letter, Subject: "Continuation of Planning and Engineering Studies," establishing interim guidance for requirements and procedures for accomplishing and reporting Continuation of Planning and Engineering studies and directing District to proceed with CP&E studies.

b. SPDED-TC 12 April 1982 letter, Subject: "Redbank and Fancher Creeks, General Design Conference," summarizing discussions and decisions during the General Design Conference.

c. SPDED-W (SPKED-D/10 Aug 84) 5th End, 31 May 1985, Subject: "Redbank and Fancher Creeks Project, Freeboard and Riprap Considerations," approving the concepts and criteria on which project embankment freeboard and erosion control are based.

d. ER 1110-2-1150, 24 June 1985 "Engineering after Feasibility Studies."

2. In accordance with ER 1110-2-1150, dated 24 June 1985, 15 copies of the Final General Design Memorandum (GDM) are enclosed for your concurrence and forwarding to OCE for approval.

3. The Final GDM reflects comments made by SPD and non-Federal interests. SPK responses addressing SPD's review comments on the Draft GDM are contained in SPKED-D endorsements 2 and 4 to SPKED-D letter of 9 September 1985, Subject: Redbank and Fancher Creeks, California, Draft General Design Memorandum.

4. Appendix A contains the detailed hydrologic information on which project designs are based. Appendix B contains the Fish and Wildlife Coordination Act Report dated 23 December 1985 and letters from the Fish and Wildlife Service and the California State Department of Fish and Game commenting on the Selected Plan. SPK letters responding to their comments also are included. Appendix C contains a Preliminary Draft Local Cooperative Agreement which reflects current cost sharing criteria applicable to the project. Appendix D - Letters of Intent and Support includes the 9 October 1985 Letter of Intent from the local sponsor, Fresno Metropolitan Flood Control District,

SPKED-D
SUBJECT: Redbank and Fancher Creeks, California, Final General Design Memorandum

which was previously transmitted through your office to OCE to qualify the project as a potential new construction start in FY-87.

5. We are currently proceeding with Feature Design Memoranda analyses and designs so that Continuation of Planning and Engineering studies can be completed on schedule in FY-86, allowing for the scheduled construction start in FY-87.

WAYNE J. SCHOLL
Colonel, CE
Commanding

SACRAMENTO DISTRICT
RESPONSES TO ENGINEERING DIVISION COMMENTS ON
REDBANK AND FANCHER CREEKS, CALIFORNIA
DRAFT GENERAL DESIGN MEMORANDUM

1. Pages XVII and XVIII, Syllabus.

a. Closer attention has been given to proper rounding of the costs and benefits of this project in accordance with ER 11-2-240, Appendix B. This is reflected on Pages xix, xxiii, xxv, xxvii, xxix, in Tables 28 through 43, and elsewhere in the Final General Design Memorandum (GDM).

b. The second sentence, next to last paragraph, Page xvii, is considered to be correct, consistent with the Final General Design Memorandum, and therefore remains unchanged.

c. The annual benefits have been inserted after the annual costs on Page xix.

2. Chapter VII and Appendix C. As agreed between SPD and SPK, a Supplemental Environmental Impact Statement is not necessary because the project features impacting fish and wildlife resources which required mitigation were eliminated by the Assistant Secretary of the Army (ASA) (Civil Works) when he transmitted the project to Congress for authorization. The ASA's changes are reflected in the Record of Decision. Also, all of the environmental effects resulting from the Selected Plan were fully evaluated in the Final Environmental Impact Statement (FEIS), with the Selected Plan having less impacts than the plan presented in the FEIS. The results of an environmental assessment of the Selected Plan performed during the GDM studies are presented in Chapter VII - Environmental and Cultural Resources. A discussion of Cultural Resources requirements is covered in item 4 below.

3. Paragraph 52, Coordination. Appendix B - Environmental Resources contains the current Fish and Wildlife Coordination Act Report dated 23 December 1985, which reflects the Selected Plan presented in the Final GDM, along with letters from the Fish and Wildlife Service and the California State Department of Fish and Game commenting on the Selected Plan. The District's responses to these comments also are contained in Appendix B.

4. Paragraph 54, Cultural Resources.

a. The requirements of the 36 CFR 800 procedures are normally undertaken and continue throughout the project planning and design process. These procedures are being followed in accordance with ER 1105-2-55, EP 1105-2-55, and the design schedule previously submitted to SPD and OCE. Therefore, because the FEIS addresses this continuing procedure a supplement to the FEIS is not required.

b. As a result of the 1983 intensive survey by the University of California, Los Angeles (UCLA), eight cultural sites have been identified in the project area. Six of these may be eligible for the National Register of Historic Places. Preservation and/or mitigation measures will be developed for those sites that are determined eligible in consultation with the State Historic Preservation Officer and the Advisory Council on Historic Preservation, as sheduled (see response 4. a., above).

c. The results of the 1983 UCLA field study are being prepared in report form and will be submitted to the State Historic Preservation Officer, the National Park Service, and interested professionals for review. The steps to avoid impact to the potential National Register sites are described in Chapter VII - Environmental and Cultural Resources.

d. The information provided by UCLA on the proposed mitigation and/or preservation actions is the basis for the estimated cost shown for cultural resources mitigation in Chapter XV - Cost Estimates.

5. Chapter XV, Cost Estimates, Tables 31-35.

a. The term "Environmental Considerations" has been replaced with the term "Structure and Site Enhancement" in Chapter XV - Cost Estimates. Both terms represent landscaping, beautification, and architectural treatments anticipated to be developed in detail during succeeding design efforts. "Environmental Considerations" is a standard term which has been used in most of the DM's prepared by SPK during the last 15 years (see DM's on Hidden and Buchanan dams, New Melones dam, Lakeport dam, Marysville dam, Merced County Streams, and Cottonwood Creek dam).

b. The reservoir clearing cost estimates have been developed in accordance with the reservoir clearing plan presented in Chapter X - Reservoir Clearing.

6. Chapter XVI, Economics of the Selected Plan.

a. The only change to the benefits presented in the Feasibility Report is deletion of the recreation and unemployment benefits. The reasons for deletion of these benefits were given in the Draft GDM. Page 207 of Chapter XVI - Economics of the Selected Plan has been reorganized to more easily identify this information. Project year one (1) for the period of analysis was changed from 1985 to 1990 to more accurately represent the project construction schedule. Designating 1985 as project year one (1) would be indefensible when the Final GDM is dated February 1986.

b. Pages 202 and 106, Interest During Construction. The GDM remains unchanged. Interest during construction was considered as per references cited by SPD. The project starts producing benefits as soon as Pup Creek and Alluvial Drain Detention Basins are constructed; they have one-year construction schedules. Thus interest during construction was not calculated. This was explained in the Draft GDM.

ENGINEERING DIVISION COMMENTS
ON
REDBANK AND FANCHER CREEKS, CALIFORNIA
DRAFT GENERAL DESIGN MEMORANDUM

1. Pages XVII and XVIII, Syllabus

a. Here and elsewhere in the report, round all total cost and benefit amounts to three significant figures. Other amounts should be rounded as much as possible.

b. In the next to last paragraph on Page XVII, rewrite the second sentence correctly.

c. On Page XVIII, insert the annual benefits after the annual costs at the top of the page. (SPDPD)

2. Chapter VII and Appendix C. Supplement the EIS to cover the change in the plan, probable impacts of the new plan, and newly recognized impacts to significant resources. Elimination of a relatively large permanent pool and public recreation facilities constitutes a substantial change relevant to environmental concerns from the plan that was presented in the EIS. The alternative of constructing the project without the recreation pool and facilities was not considered in the EIS. Likewise, the EIS did not explore related impacts, such as the effects of excavating for borrow material around the important riparian vegetation and subjecting the vegetation to a new pattern of flooding as a result of being left in the bottom of the pool. Also, the fact that a site eligible for the National Register of Historic Places will be impacted by the project requires a supplement to the EIS. (A SIR or EA cannot be used instead of an actual supplement in these cases.) (SPDPD)

3. Paragraph 52, Coordination. Include in the GDM letters of the Fish and Wildlife Service and California Department of Fish and Game pursuant to the Coordination Act concerning the revised plan and the elimination of mitigation. (SPDPD)

4. Paragraph 54, Cultural Resources. The EIS deferred consideration of the significance of cultural resources until the project was authorized and a more detailed survey of cultural resources had been completed. (EIS, paragraphs 4.08 and 9.15(1)). The draft GDM reports that an intensive survey undertaken in 1983 found five sites eligible for listing in the National Register of Historic Places, one of which will be impacted by construction, but that coordination with the State Historic Preservation Office (SHPO) and the Advisory Council on Historic Preservation (ACHP) had not yet been initiated. The cost estimate (pages 172 and 177) includes items for cultural resource preservation at Big Dry Creek Dam and Fancher Creek Dam. Before the GDM can be approved the following actions must be completed:

a. Complete the requirements of 36 CFR 800.

b. Supplement the EIS to cover the newly found impact to a site on or eligible for listing on the National Register. A supplement is necessary since any adverse impact to a National Register-eligible site is by definition significant.

ENCL. 1

c. Explain in the GDM what steps will be taken to avoid all impact to the other Register-eligible sites in the construction area.

d. Include in the GDM information to justify the amounts shown for cultural resources preservation in Tables 31 and 32. The reason given in Table 38 -- that this is allowed by law -- is not adequate. The amount could be more or less depending on the results of studies and required coordination with the SHPO and the ACHP. (SPDPD)

5. Chapter XV, Cost Estimates, Tables 31-35.

a. Replace the item "Environmental Considerations" with more precise terminology. Notice that an item cannot be added to cost estimates for compliance with the specification "Environment Protection." If this item is for seeding, planting, esthetic treatment, or such, those items should be listed separately.

b. Delete items for reservoir clearing, except for 80 acres in Table 32 (Fancher Creek Dam), as Chapter X, Reservoir Clearing, states that no clearing will be required other than one 80-acre vineyard. (SPDPB)

6. Chapter XVI, Economics of the Selected Plan.

a. ER 1110-2-1150 requires explanantions for any revisions to the benefits presented in the feasibility report. Additional explanations are needed given that Principles and Guidelines are used as guidance for evaluation, several types of benefits have been deleted, and the base year and period of analysis have been extended five years from 1985-2085 to 1990-2090.

b. Pages 202 and 206, Interest During Construction. Excluding interest during construction because the construction period is two years or less is no longer allowable. Interest during construction must be computed up to the time the project starts producing benefits or up to the time when the project is placed in operation. (See EP 1105-2-45, Paragraph 2-6, and P&G, Paragraph 2.12.4(b).) (SPDPD)

7. By separate action, submit 4 revised project cost estimate (PB-3) to reflect the revised project cost estimates presented in the subject GDM. (SPDPB)

8. Paragraph 39d(1).

a. If the referenced curves (near field hard site) were used to determine peak bedrock accelerations, then determine peak bedrock accelerations, from published attenuation curves. Published attenuation curves by Seed and Idriss (1984) indicate the following peak bedrock acceleration: M6.2 a=0.62g, M7.1 a=0.7g at Dry Creek; M6.2 a=0.56g, M7.1 a=0.65g at Fancher Creek. Revise tabulation as required.

b. The mean acceleration value and duration from the Marcuson, Krinitzsky reference are low due to the following:

1.) the very near field location of the dam sites in relation to the Clovis fault. The Clovis fault as inferred passes directly under Big Dry Creek dam site and within 3.2 kilometers of Fancher Creek dam site.

REDBANK AND FANCHER CREEKS, CALIFORNIA
GENERAL DESIGN MEMORANDUM

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SYLLABUS

The purpose of the Redbank and Fancher Creeks, California local flood protection project is to reduce losses from floods in the Fresno-Clovis Metropolitan area and on surrounding agricultural lands. This General Design Memorandum presents the analyses and designs completed subsequent to submission of the Feasibility Report to Congress for authorization.

The existing Big Dry Creek Dam on Dry Creek will be raised about 7.6 feet to increase the gross pool capacity from 16,500 acre-feet to 31,785 acre-feet, essentially eliminating flooding on 11,100 acres. The resulting level of flood protection will be increased from the current 60-year level to Standard Project Flood (SPF) level of protection. The Dry Creek Crossing of the Friant-Kern Canal will be modified to insure passage of the SPF into the reservoir. The two existing outlet works and spillway will be replaced. The reservoir operation will remain the same.

Fancher Creek Dam will be located adjacent to and east of the Friant-Kern Canal. It will have a capacity of 10,304 acre-feet and in conjunction with Redbank Creek Detention Basin will provide 200-year level of protection to about 26,300 acres. The ungated outlet works and spillway are combined into one structure so that the existing Fancher Creek overchute of the Friant-Kern Canal can be used to discharge flows to Fancher Creek, west of the canal.

Pup Creek Detention Basin will be located on Pup Creek, a tributary to Dry Creek. The 495 acre-foot basin will be partially excavated and partially embankment contained. It is designed to control the 200-year flood with a maximum release of 25 cfs. The outlet works will be ungated. Embankment will be no more than 3 feet above natural ground and no spillway will be provided.

Alluvial Drain Detention Basin will be located on Alluvial Drain, a tributary to Dry Creek. The 385 acre-foot basin will be completely excavated. It is designed to control the 200-year flood with a maximum release of 25 cfs. The outlet works will be ungated and no spillway will be provided. The project facilities on Pup Creek and Alluvial Drain will reduce flooding on about 500 acres.

Redbank Creek Detention Basin will be located on Redbank Creek. The 940 acre-foot basin will be partially excavated and partially embankment contained. It is designed to control the 200-year flood with a maximum release of 200 cfs. The outlet works will be gated with automatically controlled, constant downstream-level gates. Embankment will be no more than three feet above natural ground and no spillway will be provided.

The total first cost of the project is $60,100,000 and the corresponding total equivalent annual cost is $5,380,000. Estimated first and annual costs to the United States are $49,600,000 and $4,250,000, respectively. Estimated non-Federal first and annual costs are $10,500,000 and $1,130,000, respectively. These costs are based on adoption and implementation of the Administration and Senate Majority Leadership cost-sharing policy reported by the Senate Environment and Public Works Committee 1 August 1985. Cost sharing based on traditional cost-sharing methods is also included in this GDM for comparative purposes. The benefit to cost ratio is 1.6 to 1.

REDBANK AND FANCHER CREEKS, CALIFORNIA
PERTINENT DATA

TOTAL PROJECT

First Cost	
Federal	$49,600,000
Non-federal	$10,500,000
Total first cost	$60,100,000
Annual Cost	
Federal	$ 4,250,000
Non-federal	$ 1,130,000
Total annual cost	$ 5,380,000
Annual Benefits	$ 8,480,000
Benefits/Costs	1.6 to 1

BIG DRY CREEK DAM AND RESERVOIR

General		
County	Fresno	
Streams	Dry Creek	
	Dog Creek	
Drainage Area	81.7 square miles	
First cost		
Federal	$12,300,000	
Non-federal	$ 2,000,000	
Total	$14,300,000	
Annual cost		
Federal	$ 1,061,200	
Non-federal	$ 310,450	
Total	$ 1,371,650	
Flows		
Mean annual @ Damsite	13 cfs	
SPF peak inflow	17,900 cfs	
SPF peak outflow	700 cfs	
SDF peak inflow	45,400 cfs	
SDF peak outflow	33,400 cfs	
Reservoir		
Storage		
Residual pool (existing)	Elev. 400.0	216 acre-feet
Gross pool (SPF)	Elev. 433.2	31,785 acre-feet
SDF pool	Elev. 439.6	47,832 acre-feet
Sediment		1,120 acre-feet
Maximum flood storage		30,665 acre-feet
Surface area		
Residual pool (existing)		64 acres
Gross pool		2,212 acres
SDF pool		2,767 acres

Pertinent Data (Continued)

<u>Embankment</u>	
Type	Homogeneous Rolled Earth Fill
Crest Elev.	442.6
Embankment length	25,310 feet
U/S slope	Toe to elev. 438.5 1V on 3H
	Elev 438..5 to crest 1V on 2H
D/S slope	Toe to Elev. 438.5 1V on 2.25H
	Elev. 438.5 to crest 1V on 2H
Freeboard above maximum SDF pool	3.0 feet
Wave runup	2.51 feet
Maximum section height	45 feet
Crest Width	25 feet
<u>Spillway</u>	
Type and location	Concrete OGEE, Sta. 247+30
Crest Elev.	433.2
Crest length	550 feet
Maximum discharge	33,400 cfs
SDF pool Elev.	439.6
Stilling basin	
Width	550 feet
Length	31.0 feet
Apron Elev.	419.9
Design discharge at TW/D2=1.0	33,400 cfs
<u>Little Dry Creek Outlet Works</u>	
Type	Control tower with dual gated intake, adjustable service and emergency gates, single conduit and stilling basin
Design release	700 cfs @ w/s Elev. 416.4
Maximum regulated release	700 cfs
Tower	
Type	Reinforced concrete, dry well
Height	50.6 feet from invert to roof
Gates	
Service gate	
Number	2
Type	Wedge lock type slide
Size	3.0 feet wide, 6.5 feet high
Emergency	
Number	2
Type	Wedge lock type slide
Size	3.0 feet wide, 6.5 feet high
Operation	Electric with manual backup
Conduit	
Type	Single cut and cover concrete box
Size	6.5 feet high, 5.0 feet wide
Length	130.82 feet
Invert Elev. at tower	403.0
Invert Elev. at stilling basin	401.0
Invert Slope	0.0129

Stilling basin	
Width	16.5 feet
Length	32.0 feet
Apron Elev.	387.0
Design discharge at TW/D2 = 1.0	700 cfs

<u>Big Dry Creek Outlet Works</u>

Type	Control tower with adjustable service and emergency gates, single conduit and impact basin
Design release	150 cfs @ Pool Elev. 415.0
Tower	
Type	Reinforced concrete, dry well
Height	53.6 feet from invert to roof
Gate	
Service gate	
Number	1
Type	Wedge lock type slide
Size	3.0 feet wide, 3.0 feet high
Emergency	
Number	1
Type	Wedge lock type slide
Size	3.0 feet wide, 3.0 feet high
Operation	Electric with manual backup
Control section	3 feet by 3 feet
Conduit	
Type	Single cut and cover concrete box
Size	3.0 feet high, 3.0 feet wide
Length	188.2 feet
Invert Elev. at tower	400.0
Invert Elev. at stilling basin	394.5
Invert Slope	0.02954
Impact basin	
Width	12.0 feet
Length	17.0 feet
Apron Elev.	392.5
Design discharge	150 cfs

<u>Dry Creek Crossing</u>

Siphon Headwall	
Type	Cast-in-place reinforced concrete
Length	65.0 feet
Elevation, top	470.0 feet
Freeboard	3.0 feet
Wingwalls	
Type	Cast-in-place reinforced concrete
Length	40.0 feet
Elevation, top	470.5 feet
Freeboard	3.5 feet

Pertinent Data (Continued)

Slope Protection	Angular riprap
Embankments	
New	
Crest Elevation	471.0 feet
Top Width	10.0 feet
Side slopes	1V on 2.25H
Freeboard	3.0 feet
Raised - Friant - Kern Canal, left bank	
Crest Elevation	470.0 feet
Top Width	20.0 feet
Side slope	1V on 2.25H
Freeboard	3.0 feet
Raised - Dog Creek Diversion structure	
Crest Elevation	471.0 feet
Top Width	20.0 feet
Side slopes	1V on 2.25H
Freeboard	3.0 feet

Pertinent Data (Continued)

FANCHER CREEK DAM AND RESERVOIR

General		
County	Fresno	
Streams	Fancher Creek	
	Hog Creek	
Drainage Area	28 square miles	
First cost		
Federal	$16,600,000	
Non-federal	$ 5,500,000	
Total	$22,100,000	
Annual cost		
Federal	$ 1,437,200	
Non-federal	$ 524,200	
Total	$ 1,961,400	
Flows		
RDF peak inflow	5,790 cfs	
RDF peak outflow	100 cfs	
SDF peak inflow	20,600 cfs	
SDF peak outflow	7,100 cfs	
Reservoir		
Storage		
Gross pool (200-year)	Elev. 480.5	10,304 acre-feet
SDF pool	Elev. 490.3	20,900 acre-feet
Sediment		396 acre-feet
Maximum storage		9,908 acre-feet
Surface area		
Gross pool		915 acres
SDF pool		1,354 acres
Embankment		
Type	Homogeneous Rolled Earth Fill with impervious core	
Crest Elev.	493.3	
Crest width	25 feet	
Embankment length	16,896 feet	
U/S slope	Toe to elev. 490.0	1V on 3H
	Elev. 490.0 to crest	1V on 2H
D/S slope	Toe to crest	1V on 2H
Freeboard above maximum SDF pool	3.0 feet	
Wave runup	1.9 feet	
Maximum section height	45.5 feet	
Crest width	25 feet	
Spillway		
Type and location	High concrete OGEE	
Crest Elev.	480.5	
Crest length	60 feet	
Max. discharge	7,100 cfs	
SPF pool Elev.	490.3	

Outlet Works	
Type	Ungated, box conduit, discharge to spillway chute, flow restrictor plate control
Conduit	
Dimensions	3 feet x 3 feet
Invert elevation	457.78
Slope	0.0
Design release (max.)	100 cfs @ w/s Elev. 480.5
Overchute	
Type	Existing
Invert elevation	457.78
Length	107.33 feet
Width	30.0 feet
Stilling basin	
Width	40.0 feet
Length	68.0 feet
Apron elevation	435.7
Design discharge at TW/D2 = .9	7,100 cfs

Pertinent Data (Continued)

PUP CREEK DETENTION BASIN

General		
County	Fresno	
Stream	Pup Creek	
Drainage area	4.26 square miles	
First cost		
Federal	$ 4,100,000	
Non-federal	$ 700,000	
Total	$ 4,800,000	
Annual costs		
Federal	$ 353,700	
Non-federal	$ 64,600	
Total	$ 418,300	
Flows		
200-year peak inflow	315 cfs	
200-year peak outflow	25 cfs	
Reservoir		
Storage		
Gross pool (200-year)	Elev. 376.8	495 acre-feet
Sediment		0 acre-feet
Maximum flood storage		495 acre-feet
Surface area		64 acres
Basin		
Invert Elev. at outlet works	366.0	
Excavated side slopes	1V on 8H	
Invert slope	0.0001	
Embankment		
Type	Earth/soil cement	
Crest Elev.	376.8	
Crest width	10 feet	
Embankment length	710 feet	
U/S slope	Toe to crest 1V on 8H	
D/S slope	Toe to crest 1V on 2H	
Freeboard	0.0 feet	
Maximum height	3.0 feet	
Outlet Works		
Type	Precast reinforced concrete pipe	
Diameter of conduit	3.0 feet	
Length	66.0 feet	
Type of control	Flow restrictor plate at intake	
Maximum release	25 cfs	
Energy dissipation	Rock lined scour hole	
Slope		

Exit Channel	
Open channel	
Length from outlet works	640 feet
Bottom width	10 feet
Side slopes	1V on 2H
Invert slope	0.0003
Manning's n value	0.035
Capacity	25 cfs
Maximum depth of excavation	10 feet
Access Road	
Length	640 feet
Type	SABC
Lane width	12 feet
Pipe	
Length	2,320
Invert slope	0.0003
Capacity	40 cfs
Land required for channel and road	1.1 acres
Fencing	
Type	Barbed wire
Length	1,280 feet

Pertinent Data (Continued)

ALLUVIAL DRAIN DETENTION BASIN

General		
County	Fresno	
Stream	Alluvial Drain	
Drainage area	2.65 square miles	
First cost		
Federal	$ 3,300,000	
Non-federal	$ 500,000	
Total	$ 3,800,000	
Annual costs		
Federal	$ 284,800	
Non-federal	$ 46,550	
Total	$ 331,350	
Flows		
200-year peak inflow	340 cfs	
200-year peak outflow	25 cfs	
Reservoir		
Storage		
Gross pool (200-year)	Elev. 386.4	385 acre-feet
Sediment		0 acre-feet
Maximum flood storage		385 acre-feet
Surface area		57.4 acres
Basin		
Invert Elev. at outlet works	377.9	
Excavated side slopes	1V on 8H	
Invert slope	0.0001	
Embankment	None	
Outlet Works		
Type	Precast reinforced concrete pipe	
Diameter of Conduit	3.0 feet	
Length	112 feet	
Type of control	Flow restrictor plate at intake	
Maximum release	25 cfs	
Energy dissipation	Rock lined scour hole	
Slope	0.0003	
Exit Channel		
Length from outlet works	2,000 feet	
Bottom width	5.0 feet	
Side slopes	1V on 2H	
Invert slope	0.00003	
Manning's n value	0.035	
Design capacity	25 cfs	
Maximum depth of excavation	3 feet	
Access Road		
Length	2,000 feet	

Pertinent Data (Continued)

Type	6-inch SABC
Lane width	12 feet
Land required for channel and road	2.4 acres
Fencing	Barbed wire, 4,000 feet

REDBANK CREEK DETENTION BASIN

General		
County	Fresno	
Stream	Redbank Creek	
Drainage area	25.2 square miles	
First cost		
Federal	$12,200,000	
Non-federal	$ 1,800,000	
Total	$14,000,000	
Annual costs		
Federal	$ 1,052,600	
Non-federal	$ 184,200	
Total	$ 1,236,800	
Flows		
200-year peak inflow	570 cfs	
200-year peak outflow	200 cfs	
Reservoir		
Storage		
Gross pool (200-year)	Elev. 349.3	940 acre-feet
Sediment		0 acre-feet
Maximum flood storage		940 acre-feet
Surface area at gross pool		168 acres
Basin		
Invert Elev. at control structures	342.2	
Excavated side slopes	1V on 8H	
Invert slope	0.0001	
Embankment		
Type	Earth/soil cement	
Crest Elev.	349.3	
Crest width	10 feet	
Embankment length	4,700 feet	
U/S basin slope	Toe to crest 1V on 8H	
U/S slope for Redbank Creek	Toe to crest 1V on 2H	
D/S slope (both embankments)	Toe to crest 1V on 2H	
Freeboard allowance	0.0 feet	
Maximum height	3.0 feet	
Control Structure		
Type of control	2 self regulating, constant downstream water level gates	
Energy Dissipation	Rapid expansion	
Exit channel	Existing	
Rerouted Mill Ditch		
Bottom width	12 feet	
Side slopes	1V on 3H	
Slope protection at bends	9 inch thick gabions	
Slope	0.0013	

Chapter I - Introduction

1. Purpose and Scope. - The purpose of the Redbank and Fancher Creeks, California local protection project is to reduce losses from floods in the Fresno-Clovis Metropolitan area and surrounding agricultural areas, Plate G1. This General Design Memorandum (GDM) summarizes the designs and analyses completed for the project subsequent to submission of the Feasibility Report to Congress for authorization. This GDM will serve as the basis for subsequent Feature Design Memorandums (FDM) and Contract Plans and Specifications. The currently recommended project and alternative designs investigated, detailed cost estimates, schedules for design and construction, proposed project operation and maintenance, environmental considerations, real estate and relocations requirements, and proposed cost sharing requirements are presented.

2. Project Status. - Study of the Fresno-Clovis area flood control problems was undertaken by the Corps of Engineers in response to requests by local interests to Congress.

a. Feasibility Study. -

(1) Authorization. - The Feasibility Study was authorized in two parts.

(a) Redbank and Fancher Creeks Authorization. - The Feasibility Study for providing flood protection on Redbank and Fancher Creeks was authorized on 13 June 1956 by the House of Representatives' Committee on Public Works, based on the Fresno County Stream Group reports. These reports were published in House Document No. 845, 76th Congress, 3rd Session.

(b) Big Dry Creek, Pup Creek, and Alluvial Drain Authorization. - The San Joaquin River Basin investigation for coordinated development of the water resources in the San Joaquin Basin is the basis for authorization of the Big Dry Creek, Pup Creek, and Alluvial Drain portions of the study. The investigation was authorized on 18 May 1964, also by the House Committee on Public Works, based on the Sacramento-San Joaquin Basin Streams, California report, published in House Document No. 367, 81st Congress, 1st Session.

(2) Status. - The Feasibility Report and Final Environmental Impact Statement (FEIS) for the Redbank and Fancher Creeks project were completed in February 1979 and transmitted to Congress by the Assistant Secretary of the Army (ASA) for Civil Works on 17 November 1983 for authorization. The FEIS was filed with the Environmental Protection Agency on 7 November 1980. Both documents were subsequently published as House Document No. 98-147, 98th Congress, 2nd Session, 23 January 1984. The project currently is awaiting Congressional authorization.

b. Continuation of Planning and Engineering. - Post Feasibility Study designs and analyses have been carried out under the Continuation of Planning and Engineering (CP&E) authority and have been based on the plan recommended

to Congress. The Commander of the South Pacific Division authorized the Sacramento District to conduct CP&E studies by letter dated 2 December 1981. This GDM presents the findings of the CP&E studies to date.

3. Current Recommendations to Congress. - The Feasibility Report presents a selected plan along with a National Economic Development (NED) and Environmental Quality (EQ) Plan and other plans. The Chief of Engineers recommended the selected plan when transmitting the Feasibility Report to the Secretary of the Army on 7 May 1981. However, the ASA recommended a modified NED Plan (the Recommended Plan) when transmitting the report to Congress on 17 November 1983. The Recommended Plan is the basis for the CP&E studies and, as currently designed, is described in detail in this GDM.

The difference between the Chief of Engineers plan and the Recommended Plan (currently before Congress) is elimination of the permanent recreation pool and related facilities at Big Dry Creek Reservoir from the selected plan, and reduction of the level of protection provided by Fancher Creek Dam and Redbank Creek Detention Basin from 200-year to 100-year (NED level of protection). Recreation was eliminated from Big Dry Creek Reservoir because it has been a long standing Army policy not to provide storage space in a local protection project specifically for recreation purposes. The 100 year level of protection for Redbank Creek Detention Basin and Fancher Creek Dam, the NED plan, was recommended by the ASA because it was the point at which benefits were optimized for these features during the Feasibility Study.

Although the Recommended Plan would provide a 100-year level of protection on Redbank and Fancher Creeks, the latest Fancher Creek Dam and Redbank Creek Detention Basin designs provide a 200-year level of protection for a slightly larger storage capacity as the plan recommended to Congress by the ASA. This small increase in size and relative increase in protection resulted from integrating the operation of Fancher Creek Dam and Redbank Creek Detention Basin with the network of natural channels, dual purpose irrigation canals, and existing flood control facilities in the area and optimizing the flood control operation of this system. This refined operation study showed that during a flood more of the Redbank and Fancher Creek flows could be safely passed out of the Fresno-Clovis Metropolitan Area via the Herndon Canal and thus storage requirements for the dam and detention basin could be reduced. Because the slightly larger facilities can provide a greater (200-year) level of protection, comparing the costs to the resulting benefits indicates that the new NED benefits point of optimization occurs at the 200-year level of protection. Consequently, the intent of the ASA's recommendation to Congress has been retained while the level of protection provided has increased.

4. The Project Area. - The Redbank and Fancher Creeks, California project area covers the north-central portion of Fresno County, California, between the San Joaquin River, to the north, and the Kings River, to the south. All project features are located east of the Fresno-Clovis Metropolitan area, one of three major urban-suburban areas in the San Joaquin Valley. The Fresno-Clovis Metropolitan area has a population of about 305,000. The major industry in Fresno County is agriculture. In 1950, Fresno County became the

leading agricultural producing county in the nation. This distinction remains true today. Within the project area, cultivated farming predominates on the valley floor while the eastern foothills are used primarily for livestock grazing.

a. Topography. - The topography of the project area ranges from the steep hills and ridges of the Sierra Nevada foothills, with elevations reaching 4,700 feet above mean sea level to the nearly flat alluvial plains of the valley floor. The lowest elevation in the project area is 350.0, on Mill Ditch, southeast of Clovis. All elevations cited in this GDM are in feet above mean sea level. Topography is shown on Plate H6 of the Hydrology Appendix.

b. The Watershed. - The project watershed covers about 175 square miles. The principal streams in the area fall into three stream systems. They are the Dry and Dog Creek system; the Redbank, Fancher, and Hog Creek system, and the Pup Creek and Alluvial Drain system, tributaries to Dry Creek. This network of streams collects storm runoff from the foothills and conveys it down to the valley floor, through the Fresno-Clovis Metropolitan area to Fresno Slough (Kings River North), and finally to the San Joaquin River. Except for Dry Creek and Redbank Creek, the streams in the project area flow essentially uncontrolled. On the valley floor, the natural channels have been extensively modified so that they have become dual-use irrigation water and storm drainage conveyance channels. During the summer months flow is very low in the natural channels and very high in irrigation canals. Stream flows increase in the late Fall in response to precipitation and annual peak stream flows typically are reached during December, January, and February. Storms may occur at any time during the winter.

5. Project Features. - The project features have been designed to control damaging flood flows in the Fresno-Clovis Metropolitan area and the surrounding rural and agricultural lands. The project consists of an enlarged existing dam, one new dam, and three new detention basins.

a. Big Dry Creek Dam. - The existing Dry Creek Dam will be raised, increasing the gross pool from 16,500 acre-feet to 31,785 acre-feet. The enlarged reservoir will provide Standard Project Flood (SPF) protection to downstream areas from the combined flows of Dry Creek and Dog Creek. The existing facility provides about a 60-year level of protection. The dam embankment will be about 25,300 feet long with a maximum height of 45 feet. The two existing outlet works and the existing spillway will be replaced with similar structures. The project operation will remain virtually the same, with most flood waters released to Little Dry Creek Diversion Channel at a maximum rate of 700 cfs. In addition, the capacity of the Dry Creek Crossing of the Friant-Kern Canal will be increased to insure safe passage over the Friant-Kern Canal of the combined Dry and Dog creeks SPF flows.

b. Fancher Creek Dam. - A new single purpose flood control dam will be constructed on Fancher Creek, adjacent to and east of the Friant-Kern Canal. The dam embankment will be about 16,900 feet long with a maximum height of 45.5 feet. The reservoir will have a gross pool capacity of 10,304 acre-feet and will provide a 200-year level of protection from the combined flows of Fancher and Hog Creeks. The maximum outflow will be 100 cfs at gross pool

(spillway crest). The spillway design incorporates the existing Fancher Creek overchute of the Friant-Kern Canal (Canal Station 1126+60). Both the outlet works and the spillway will be ungated.

c. Pup Creek Detention Basin. - The Pup Creek Detention Basin will be constructed on Pup Creek just east of Temperance Avenue. The basin will have a maximum capacity of 495 acre-feet and will control a 200-year flood with a maximum outfow of 25 cfs. The storage basin will be partially excavated and partially embankment contained. The retention embankment will be 710 feet long with a maximum height of 3 feet. The outlet works will be ungated. A spillway will not be provided.

d. Alluvial Drain Detention Basin. - The Alluvial Drain Detention Basin will be constructed on Alluvial Drain just east of the Enterprise Canal. The basin will have a maximum capacity of 385 acre-feet and will control a 200-year flood with a maximum outflow of 25 cfs. The storage basin will be completely excavated, below natural ground. The outlet works will be ungated. A spillway is not required.

e. Redbank Creek Detention Basin. - The Redbank Creek Detention Basin will be constructed just north of McKinley Avenue on Redbank Creek at its present confluence with Mill Ditch. The basin will have a maximum capacity of 940 acre-feet and will control a 200-year flood with a maximum discharge of 200 cfs. The storage basin will be partially excavated and partially embankment contained. The retention embankments will be a total of 4,700 feet long with a maximum height of 3 feet. Outflow will be controlled by a pair of automatic, buoyancy controlled, constant release, tainter-type gates.

6. Protected Areas. - The enlarged Big Dry Creek Dam will essentially eliminate flooding on approximately 11,100 acres. Fancher Creek Dam and Redbank Creek Detention Basin will protect an agricultural/urban area of about 26,300 acres, and the facilities on Pup Creek and Alluvial Drain will reduce flooding on approximately 500 acres. The preproject and project flood plains for the SPF and 100 year flood are shown on Plates G3 and G4, respectively.

7. Local Involvement and Support. -

a. Local Involvement. - The Fresno-Clovis community has been involved in flood control activities in their area since at least the 1930's. Local interest in flood control has resulted in constructing Big Dry Dam and Diversion facilities in 1948, formulating the Fresno-Metropolitan Flood Control District (FMFCD) in 1955, and constructing Redbank Dam in 1962. Establishing the FMFCD is perhaps unique because it resulted from direct citizen action. The FMFCD was created by the Fresno-Metropolitan Flood Control District Act which was developed by the Citizens Action Committee. The Act, a special amendment to the State Water Code, established a quasi-joint powers authority between the City and County of Fresno. The Act was signed into law on 13 May 1955 and ratified by a 5 to 1 majority vote of the local electorate. The legislatively mandated purposes of the FMFCD center on the acquisition and construction of flood control and drainage

facilities to control and conserve flood, storm, and other waste waters. The FMFCD is the recognized local sponsor for the Redbank and Fancher Creeks project.

b. Local Support. - The persistent history and complex nature of flooding in the Fresno-Clovis Metropolitan area has resulted in local support over the last 50 years for a comprehensive flood control system. That support has been fully demonstrated on at least two occasions. The first was the outcome of the local election creating the FMFCD with the authority to pursue the design and construction of a coordinated flood control and urban drain system. The second occasion was the community wide meeting held February 28, 1969. That meeting produced representatives from approximately 75 different communities or organizations in addition to a large number of individual citizens. The result of that meeting was a strongly unified community position that supported expeditously pursuing the Feasibility Study which had been previously authorized by Congress. That position was formalized by a resolution drafted and signed by some 115 individuals in attendance. Support for the current Redbank and Fancher Creeks project is strong, as evidenced by a number of letters and resolutions adopted by citizens, special interest groups, and local public agencies in the Fresno-Clovis area, including the following:

Fresno County and City Chamber of Commerce	16 Nov 83
The Building Industry Association	16 Jun 83
Fresno County Farm Bureau	06 May 83
Central Labor Council	29 Sep 83
Fresno Irrigation District	09 Mar 83
City Council, City of Clovis	14 Mar 83
Kings River Conservation District	12 Apr 83
Resolution No. 83-94, City of Fresno	22 Mar 83
League of Women Voters	14 Jul 83
Fresno-Clovis Metropolitian Water Agencies Association	28 Jul 83
Taxpayers Association of Fresno County	13 Jul 83
Clovis Chamber of Commerce	28 Sep 83
Fresno County Board of Supervisors	22 Mar 83
Fresno Water Advisory Committee	12 May 83
Fresno Community Council	26 Apr 83

In addition, the FMFCD Board of Directors adopted Resolution No. 1198, on 14 March, 1983 to "continue the active pursuit of the responsibilities of 'Local project sponsor'". Following this resolution, the FMFCD took the formal lead as the local sponsor and stated their continuing support for the project in the following letters: 5 June 1984, supporting the plan recommended by the Chief of Engineers; 13 Sept 1984, to President Reagan urging his support for passage of the Water Resources Development Act of 1983; 18 January 1985, to Office of the Chief of Engineers (OCE) indicating a strong desire for rapid congressional authorization; and 9 October 1985, the formal letter of intent to carry the local sponsor's share of responsibility for the project. The FMFCD also was the local sponsor of AB-2113, passed by the California Legislature, and signed into law on September 29, 1985, which provides the State of California with the authority to share in the costs of the project along with the FMFCD. The only known opposition is from a few individual land owners with lands in the Big Dry Creek Dam area.

8. Local Responsibilities. - The FMFCD, with primary responsibility for flood control in the Fresno area, is the sponsor of the Redbank and Fancher Creeks local protection project. Thus, the FMFCD will be required to provide all lands, easements, rights-of-way, and all alterations and relocations of utilities, streets, bridges, buildings, storm drains, and other structures and improvements; hold and save the United States free from damages due to the construction works, except those damages due to the fault or negligence of the United States or its contractors; and assume operation and maintenance of the works after completion in accordance with regulations prescribed by the Secretary of the Army (33 CFR 208.10). These and other local responsibilities are defined in Chapter XVII - Cost Sharing and Local Cooperation Requirements and Appendix C - Preliminary Draft Cooperative Agreement.

Following construction, the project will be turned over to FMFCD for operation and maintenance. The project will be integrated into the Fresno-Clovis Master Plan for Flood Control and will be operated and maintained as part of that system. FMFCD will be responsible to meet all project operation, maintenance, and replacement requirements as prescribed by the Corps of Engineers.

9. Existing Plans and Improvements. - Numerous structures have been built in Fresno County to date to control irrigation, flood, and urban storm drain waters. The existing structures of interest to the Redbank and Fancher Creeks, California project are two flood control reservoirs, seven canals, and the Fresno-Clovis storm drain system. These are shown on Plate G2.

a. Friant-Kern Canal. - The Friant-Kern Canal, completed by the U.S. Bureau of Reclamation in 1951 as part of the Central Valley Project, traverses the study area along the base of the Sierra foothills. It flows from north to south and has a capacity of 5,000 cfs in the vicinity of the Fancher Creek Dam site. The canal, beginning at Friant Dam on the San Joaquin River, carries water south for irrigation in Fresno, Tulare, and Kern Counties. Friant Dam is located about 25 miles northeast of Fresno.

b. Big Dry Creek Dam. - Big Dry Creek Dam and Diversion is located on Dry Creek about 10 miles northeast of the City of Fresno. It consists of an earth-fill, flood retention dam with a maximum height of 37 feet, length of 20,000 feet, and appurtenant diversion facilities. It has a gross pool of 16,500 acre-feet. Completed in 1948 by the Corps of Engineers for flood control purposes, the project subsequently was transferred to the California State Reclamation Board for operation and maintenance. The Reclamation Board turned the project over to Fresno County for operation and maintenance. The Fresno Irrigation District (FID), however, actually operates the project for Fresno County. The project provides about a 60-year level of flood protection to the Cities of Fresno and Clovis and their suburban areas from floods originating above the Friant-Kern Canal by temporarily storing the flows of Dog and Dry Creek and diverting them to Little Dry Creek Diversion channel and thence to the San Joaquin River. The capacity of the diversion channel is 700 cfs.

c. Redbank Creek Dam. - Redbank Creek Dam was constructed in 1962 by FMFCD and is operated by the district. It is located on Redbank Creek between the Enterprise and Friant-Kern canals. This dam, constructed for flood control purposes, has a gross pool capacity of 1,030 acre-feet and provides a 30-year level of protection from flows originating below the Friant-Kern Canal.

d. Fresno Irrigation District System. - The canals and laterals of FID's distribution system are an integral part of the Fresno Urban Storm Drain system. The major channels are the Gould Canal, Enterprise Canal, Fresno Canal, Mill Ditch, and Herndon Canal. They cut across agricultural lands, through the Fresno-Clovis Metropolitan area, and discharge to Fresno Slough and the San Joaquin River. They are used both for delivering irrigation water and disposing of flood water from the urban and foothills drainage areas. This system is shown on Plate G2.

(1) Enterprise Canal. - The Enterprise Canal lies just downhill from the Friant-Kern Canal. It carries irrigation water from the Kings River, via the Gould Canal, to agricultural areas east of Fresno. The canal's estimated capacity varies from 350 cfs at the Gould-Enterprise Canal split to 150 cfs at the Dry Creek siphon. The canal capacity then decreases to 90 cfs before it reaches the Herndon Canal. The canal is partially incised - partially embankment contained.

(2) Gould Canal. - The Gould Canal flows from the Kings River, westward, to Dry Creek in Fresno. It lies downhill from the Enterprise Canal. The capacity of the Gould Canal ranges from 300 cfs just upstream of Redbank Creek to 150 cfs at the Redbank Creek siphon down to Dry Creek. The canal is completely incised.

(3) Fresno Canal. - The Fresno Canal is located along the southern boundary of the project area. It carries water from the Kings River, westward, to the Mill Ditch-Fancher Creek split. The estimated capacity of the Fresno Canal is 2,000 cfs.

(4) Mill Ditch. - Mill Ditch begins at the Fancher Creek Headworks and flows westward to the Herndon Canal. The capacity of Mill Ditch is 900 cfs. At the Herndon Canal, water can be diverted to the valley floor via the Dry Creek Canal or to the San Joaquin River via the Herndon Canal.

(5) Fancher Creek Headworks. - The Fancher Creek Headworks is an existing structure at the head of the Fancher Creek Canal and Mill Ditch which controls the flow split between Mill Ditch and Fancher Creek.

(6) Herndon Canal. - The Herndon Canal flows from Mill Ditch to the San Joaquin River. It is the principle outlet for drainage and flood flows from the Fresno-Clovis area. The outlet capacity of the Herndon Canal is 500 cfs.

e. Fancher Creek Detention Basin. - FMFCD currently is constructing Fancher Creek Detention Basin near the confluence of Fancher Creek and Mill Ditch. The basin will have a maximum storage capacity of 1,140 acre-feet and

will be used to reduce flood flows in the Fancher Creek Canal, below Mill Ditch and the Fancher Creek Headworks.

f. Fresno Urban Storm Drain System. - The Fresno urban storm drain system provides storage capacity for storm waters generated in the urban area, preventing or at least delaying their mixing with flood waters from the upstream watershed. The system is comprised of numerous pumping plants, canals, groundwater recharge/detention basins, and storm drains. FMFCD is responsible for this system and currently owns land for 86 basins. Seventy-four (74) basins are completed or under construction. An additional 36 basins are planned, but the land has not been acquired. The system stores storm water and moves excess water out of the area through a series of pumping stations and channels via Herndon Canal, Dry Creek, and Fancher Creek to either the San Joaquin River or the valley floor west of Fresno. The system's residential area street inlets and laterals are sized for the 2-year local flood event and the highly developed commercial areas for the 6-year event. The urban detention basins are designed to control a 10-day, 100-year flood. The City of Clovis is planning an extension of this storm drain system along Pup Creek in expectation of urban expansion. The City of Clovis' proposed expansion calls for a single 48-inch diameter buried pipe with a capacity of 40 cfs. The design of this storm drain extension is being coordinated with the Corps of Engineers' design for the Pup Creek Detention Basin exit channel to insure compatibility as well as proper operation of the Dention Basin.

10. General Water Resource Problems. - A review of the water resource and related problems and needs in Fresno County shows that water resource development has not kept up with the demand for flood control, water supplies, and water based recreation. From 1940 to 1985, the Fresno-Clovis Metropolitan area experienced an urban population compounded growth rate of about 3.7 percent per year. During the same 45-year period, California's total population increased at a compound rate of 2.7 percent per year. Along with this growth in population, the personal per capita income for Fresno has increased an average of about 1.6 percent per year from 1950 to 1985. This has led to a substantial increase in urban residential construction, expanding the boundaries of the Fresno-Clovis Metropolitan area. Meanwhile, in the rural unincorporated areas small farms and 2 to 5-acre ranchettes have become increasingly popular with some subdivision type development taking place. Many of these ranchettes and outlying subdivisions are located between the Fresno-Clovis urban area and the Friant-Kern Canal. Most of the areas prone to flood damages in Fresno County lie downstream from the proposed project features, Plates G3 and G4.

11. Flooding Problems. - The greater Fresno-Clovis Metropolitan area receives runoff from two general sources. The first is the high elevation, steep terrain lying north and east of the Friant-Kern Canal. The second is the more intensely developed flatland flood plain areas, south and west of the Friant-Kern Canal. The nature of flooding from high elevation runoff is largely a function of geology and topography, with little impact on the runoff resulting from man's activities. In contrast, flooding resulting from lower watershed runoff is greatly impacted by man's activities.

a. Flood Characteristics. - Floods in the project area result from large general rainstorms which occur during the late Fall and early Winter or from cloudburst storms which occur during early Fall or early Spring. General rain floods last several days and generally are of the low velocity, shallow, sheet flow type. Areas and depths of flooding under current flood plain development conditions are shown in Table 1. Flooding occurs when runoff enters the dual use irrigation/storm drain system, combines with any irrigation flows in the system, and exceeds channel capacities, overtopping the banks and flowing out over adjacent lands. In some cases, the points of overbank flow are predictable, such as known channel restrictions. In many cases, however, the points of overflow are not predictable. Rodent burrows, vandalism, scouring, or embankment saturation can lead to breaks in canal embankments. Flooding also occurs when storm drain runoff must flow overland for lack of an available channel. The flooding problem is compounded by ponding of local runoff.

b. Historic Flooding. - Flooding has occurred in the project area on an average of about once in every 10 years. It is likely that flooding occurred in Fresno County during the winters of 1861-62, 1867, 1884, 1886, 1890, and 1906. Since 1907, when more accurate records were kept, extensive flooding has occurred in 1914, 1915, 1916, 1938, 1955, 1956, 1958, and 1969, 1978, and 1982-83. Information from the 1955, 1956, 1969, and 1978 floods characterizes the extent of and damages resulting from flooding which has

Table 1

Areas and Depths of Flooding
Existing Conditions

Stream Group	Flood Event	Area Flooded (Acres)	Maximum Depth of Flooding (Feet)
Redbank and Fancher Creeks	50 Year	9,600	2.5
	100 Year	20,800	2.7
	Standard Project Flood	33,700	3.7
Big Dry Creek	50 Year	0	0
	100 Year	6,400	2.4
	Standard Project Flood	11,100	4.2
Pup Creek and Alluvial Drain	50 Year	3,200	2.1
	100 Year	4,000	2.7
	Standard Project Flood	6,500	3.8

occurred in the vicinity of the proposed project features. A summary of 1955 and 1969 flood damages is shown in Table 2. Values are given in 1985 dollars.

(1) Dry and Dog Creeks. - During the 1955 flood there was no flooding on Dry Creek or Dog Creek below the existing Big Dry Creek project. About $5 million in damages were estimated to have been prevented by the Big Dry Creek project during the 1955 flood, based on the high degree of development in the Dry Creek-Dog Creek flood plain and restricted channel capacities. However, the Little Dry Creek Diversion channel suffered $25,000 in damages.

During 1969, Dry and Dog Creeks flooded about 150 acres upstream of Big Dry Creek Reservoir and 4,700 acres downstream from the reservoir. About $16 million in damages were prevented by the Big Dry Creek project. Above Big Dry Creek Reservoir, 1969 flood losses consisted of erosion of natural pasture and orchards and damage to roads and irrigation facilities. Below the reservoir, flooding was caused by local runoff and canal spills, causing damage to field crops and orchards, pasture lands, vineyards, and farm and dairy improvements. In residential areas, flood losses consisted of damage to homes and contents, landscaping improvements, the cost of evacuation and return, and the cost of dewatering basements. Commercial and industrial losses involved damages to various types of retail, wholesale, and manufacturing establishments. Losses consisted of damages to structures, fixtures, furnishings, inventories, and losses of wages and business income. In addition, power, telephone, water lines, streets and roads, public buildings, and recreation facilities were damaged along Dry Creek.

(2) Redbank and Fancher Creeks. - During 1955, flooding was caused by the large uncontrolled flows from Redbank and Fancher creeks spilling over

Table 2

1955 and 1969 Flood Damages

Stream, Year, and Reach	Area Flooded	Primary Flood Damage 1/ Agric.	Resid.	Com.	Ind & Util.	Public facil.	Total
	(Acres)	(x $1,000)					
1955 2/							
Redbank and Fancher Creeks & Misc. Tribs.	500	13	0	6	0	54	73
1969							
Dry Creek							
Above reservoir	100	95	0	0	3	155	253
Below reservoir	1,400	215	253	8	5	40	520
Dog Creek							
Above Diversion	50	2	0	0	0	28	30
Below Diversion	3,300	435	196	60	8	2	701
Redbank Creek	6,200	397	2,099	1,996	32	650	5,174
Fancher Creek	2,500	364	115	14	13	95	601
Mud Creek	1,000	120	0	0	2	3	125
Total	14,550	1,628	2,663	2,078	61	973	7,404

1/ Values in 1986 dollars
2/ Data are not available for Pup Creek and Alluvial Drain

into nearby irrigation canals. At the peak of the flood, these canals were running to capacity and overflowed in a few places to flood about 500 acres of land, 50 of which covered suburban developments within Fresno. The depth of water ranged up to 18 inches. The duration of flooding was about 4 days. Direct flood damages of about $13,000 were incurred on agricultural lands, $6,000 by commercial facilities, and $54,000 by public facilities.

During 1969, Redbank and Fancher creeks again overflowed with large amounts of flood water spilling into various irrigation canals causing them to overflow and flood additional areas. Flood damages prevented by Redbank Creek Dam were estimated to be $2 million.

(3) Pup Creek and Alluvial Drain. - Historically, considerable flooding has occurred along Pup Creek, a tributary to Dry Creek, with the most recent flooding occurring in 1969 and 1978. Sheet flow type of flooding, with low velocities and relatively shallow depths has predominated. However, such flooding has caused considerable damage to both public and private properties. On December 1955, Pup Creek overflowed its banks and flooded more than 20 homes in the vicinity of Clovis Avenue and Ninth Street. Flood waters, 2 feet deep in some places, blocked streets and disrupted traffic. Pup Creek overflowed again in March 1958 and flooded

areas along Ninth Street. Flood water ranged up to 3 feet deep, but damages were limited to streets, external residential improvements, and disruption of traffic. Flooding also occurred in February 1978 when Pup Creek again overflowed. Residential property was inundated and homes evacuated, roads and streets were closed, and traffic was disrupted. Flooding of similar characteristics has occurred along Alluvial Drain but specific information is not available on damages.

c. Flood Protection Needs. - The need for flood protection in the Fresno-Clovis Metropolitan area has been well established over the past 50 years by direct input from the local community and by studies conducted by the Corps of Engineers (1945, 1956, 1978), Soil Conservation Service (1977), Fresno-Metropolitan Flood Control District (1969, 1973), and the Citizens Project Advisory Committee (1982). Some of the needs have been partially met by the construction of Big Dry Creek Dam and Redbank Creek Dam and the establishment of the Fresno Metropolitan Flood Control District (FMFCD). However, persistent flooding continues, the value of damageable property rises, and most needs yet go unmet. Flood protection needs identified for the Fresno-Clovis area are listed in Table 3. These needs provide the basis for the Redbank and Fancher Creeks project authorization.

Table 3

Flood Protection Needs Identified for the Fresno-Clovis Area

Need	Source
Flood Control Facility on Fancher Creek	CE (1945, 1956, 1978) PM (1973),
Flood Control Facilities on Pup Creek and Alluvial Drain	PM (1973) CE (1978)
Additional Flood Control on Dry Creek	CPAC (1981)
Additional Flood Control on Redbank Creek	CE (1945, 1956, 1978) PM (1973)
Minimum 100-Year Protection on all Streams	PM (1973), CPAC (1981)
An Area-Wide, Integrated Flood Control Program Under One Authority	PM (1955,1969)
Minimal Change to Big Dry Creek Dam Operation	FMFCD (1984) CPAC (1981) CE (1978)

CE - Corps of Engineers
FMFCD - Fresno Metropolitian Flood Control District
CPAC - Citizens Project Advisory Committee
PM - General community statements from public meetings
SCS - Soil Conservation Service

12. Other Problems and Needs. - The Feasibility Study, and other studies, have identified other water resource management problems and needs in Fresno County. These include the need for more water supplies, water based recreation facilities, integrated water resource management capabilities, and hydropower production.

a. Water Supply. - The water supply problems and needs of the Fresno-Clovis Metropolitan area are identified in the Feasibility Report. They include both the need for additional irrigation, industrial, and municipal supplies and the problems of efficiently managing water storage, distribution, drainage facilities, and groundwater use.

(1) Irrigation Water Storage. - About 17,500 acre-feet of Class II (non-dependable) irrigation water from Millerton Lake are provided to Fresno Irrigation District (FID) under an existing agreement with the U.S. Department of Interior, Bureau of Reclamation. FID presently is unable to use all of this water. The water is available only during years of high runoff and generally has to be taken during the months of March, April, and May. At this time FID is trying to use all of its available Kings River water while not exceeding the flood storage capacity of Pine Flat Reservoir. FID feels that all of this Class II water could be used beneficially within the District in July, August, and September and perhaps October if storage space were available to retain the water from March through October. Big Dry Creek Dam appeared capable of beneficially storing this water.

According to ER 1105-2-20, the Department of Interior has the lead and responsibility for providing irrigation water storage. Section 8 of the Flood Control Act of 1944 provides that Corps' reservoirs may include water storage for irrigaton only upon the recommendation of the Secretary of the Interior in conformity with Reclamation Law. Federal participation in storage of irrigation water has to meet the criterion of providing a positive contribution to the National Economic Development (NED) objective, as presented in the Water Resources Council's "Principles and Standards for Planning Water and Related Land Resources," (1973), prepared under the authority of Section 103 of the 1965 Water Resources Planning Act. The Bureau of Reclamation determined that no net benefits would accrue to the NED objective from storage of irrigation water in the enlarged Big Dry Creek Reservoir. Thus, irrigation storage has not been included as a project purpose for the enlarged Big Dry Creek Dam or any of the other proposed project features. This has not been investigated further, in accordance with agreements reached during the April 1982 General Design Conference.

(2) Ground Water Overdraft. - Groundwater supplies all domestic water needs of the Fresno-Clovis area and approximately 50 percent of the agricultural needs in the FID. Thus, any adverse impacts on either groundwater quality or quantity could have severe repercussions on any future development. According to studies of the U.S. Geological Survey and Fresno County Public Works Department (FCPWD, 1976), groundwater levels in most of the project area have been relatively stable over the past several years. However, localized areas are beginning to experience low well yields and high nitrate concentrations. As the Fresno-Clovis Metropolitan area grows, the demand for groundwater is expected to increase.

Redbank, Fancher, and Dry Creek basins are water deficient areas and serve as recharge sources for the percolation of local surface flows to underground basins. However, groundwater improvement is not a project purpose because of lack of an evaluation method to show economical justification for beneficial groundwater recharge from the project features in accordance with ER 1105-2-40. Incidental ground water recharge will occur with the project from the temporary flood water storage and resulting longer periods of controlled downstream flows.

b. Recreation. - The California Parks and Recreation Information System indicates the Fresno-Clovis Metropolitan area has an unmet demand of about 540,000 recreation days per year for picnicking, non-powered boating, angling, and day-use facilities. Although the possibility of providing recreational facilities at all project features was investigated, only recreation at Big Dry Creek Reservoir proved to be economically justified. However, as stated in ER 1105-2-20, it has been a long standing Army policy to formulate local flood protection projects for flood control, and then add recreation facilities which are compatible with the facilities and operation of the basic flood control project. The addition of permanent storage in Big Dry Creek Reservoir for recreation is not consistent with this policy. Thus, the Assistant Secretary of the Army in his letter of 17 November 1983, transmitting the Feasibility Report to Congress for authorization, recommended deleting the 4,000 acre-foot permanent recreation pool at Big Dry Creek Reservoir.

c. Hydroelectric Power. - The potential of providing hydroelectric power in connection with the Redbank and Fancher Creeks project was investigated during the Feasibility Study. The conclusion that the intermittent nature of the streams and the lack of adequate storage sites in the project area precludes the economic development of hydroelectric power still stands. In a 3 February 1977 letter, the Federal Power Commission concurred with this conclusion.

d. Dam Safety Assurance Program. - The purpose of the Dam Safety Assurance Program (DSAP) investigation of the existing Big Dry Creek Dam and Diversion is to assess the safety of the facilities during a Probable Maximum Flood (PMF) event and to prevent innundation and damages to non-federal properties resulting from project diversions of Dry and Dog Creek flows to other watersheds. Reconnaissance-level studies of Big Dry Creek Dam were completed by the Corps of Engineers in December 1984. The studies found that the spillway could safely pass the PMF without overtopping Big Dry Creek Dam. However, flows exceeding 700 cfs over the spillway would fail the Little Dry Creek Diversion dike, inflows exceeding 25,000 cfs would overtop and fail project dikes above the dam, and flows in Dry Creek would not safely pass over the Friant-Kern Canal. Moreover, overtopping of the Little Dry Creek Diversion dike would result in the inundation of a sizeable urban area that would not have been inundated prior to construction of the Big Dry Creek project. These studies currently are being reviewed by the Office of the Chief of Engineers.

Under the Redbank and Fancher Creeks' California project, Big Dry Creek Dam will be raised and the Dry Creek crossing of the Friant-Kern Canal

modified to divert and control the combined Dry and Dog Creek flows up to the SPF level. The proposed Big Dry Creek Dam Spillway will be able to safely pass a Probable Maximum Flood with 3 feet of freeboard. Additional modifications to Big Dry Creek Dam, Little Dry Creek Diversion Dike, or the Friant-Kern Canal crossing for flows greater than the SPF will be addressed during subsequent DSAP investigations.

The DSAP and Redbank and Fancher Creeks' California project were to have been carried out as a joint effort to maximize efficient use of manpower and funds and to provide an integrated solution to the local flooding and dam safety problems. However, DSAP scheduling and funding delays preclude, at this time, an integrated effort.

13. Introduction. - During Continuation of Planning and Engineering (CP&E) studies, the designs developed for the plan currently recommended to Congress (the Recommended Plan) and presented in the 1978 Feasibility Report were refined. Alternative designs were developed and the least cost method of providing the required storages and maximum allowable releases was used to identify the Selected Plan. The Selected Plan, described in detail in Chapter IV - Description of the Selected Plan, reflects the recommendations contained in the Assistant Secretary of the Army's (ASA) 17 November 1983 letter to Congress regarding recreation, and reflects changes in some of the basic assumptions on which the designs for the project features were based. These changes were made subsequent to completion of the Feasibility Report and resulted in changes to the land available for the project, the reservoir sizes, and acceptable operating procedures for the completed project. These changes in assumptions are described below. Although the design of the Selected Plan does not completely coincide with the Recommended Plan, the intent of the Recommended Plan has been retained.

a. Recreation. - Although a water based recreation function at Big Dry Creek Reservoir was shown in the feasibility studies to be economically justified it was not recommended by the ASA to Congress. This decision was based on a long standing Army policy not to provide storage at a local protection project specifically for recreation purposes. In general, recreation facilities not dependent on storage requirements above those required for flood control could be provided. However, the Fresno Metropolitan Flood Control District (FMFCD) has indicated, by letter dated 18 July 1985, that they are interested only in supporting water based recreation. Thus, the plan presented in this GDM is for flood control purposes only.

b. Land Zoning Changes. - During the Feasibility Study, the Fresno County Board of Supervisors established open or "O"-zoned areas for the proposed detention basins. Soon after the Feasibility Report was completed, the Board reduced the size of the "O"-zones. This necessitated changes to the feasibility designs so that the basins could contain their design floods within the allotted "O"-zoned areas. Acquiring lands outside of the "O"-zones to maintain the detention basins as they were designed for the Feasibility Report is too costly from both a social and economic viewpoint, considering the rapid urban development in the area.

c. Operation Optimization. - The computer model of the hydrologic basin, on which the project operation was based, was updated by adding new hydrologic subareas, updating others, and updating the routing criteria to more accurately reflect the interrelationships of the creeks and canals in the project area during the SPF and 200-year design floods. Details of the refinement to the system operation model are discussed in detail in the Hydrology Appendix (Appendix A). In addition, updated hydrologic data developed subsequent to completion of the feasibility studies were used with the refined operations model to optimize the sizes of the proposed project features. Refinements to the feasibility operation studies resulted in changes in the storage requirements for the project features.

Alternative Designs Investigated

14. Big Dry Creek Dam. - Big Dry Creek Dam will be raised to provide Standard Project Flood (SPF) protection to the Fresno-Clovis Metropolitan Area from flows originating in the Dry Creek and Dog Creek watersheds. Flood waters will be diverted into Big Dry Creek Reservoir, temporarily stored, and then released at non-damaging flows to Little Dry Creek Diversion channel.

Alternative dam sections and heights, spillway types and widths, and outlet works types and locations were evaluated during CP&E studies for the proposed enlargement of Big Dry Creek Reservoir. All concepts were based on the Recommended Plan and considered the design of the existing project. Plans and sections of the selected design are shown on Plates B1 through B6. A detailed description of the Selected Plan is presented in Chapter IV - Description of the Selected Plan. A comparison of costs for the Recommended Plan and the Selected Plan is shown in Table 35 of Chapter XV - Cost Estimates.

a. Dam Height Versus Spillway Type and Width Analysis. - In order to determine the optimum combination of dam height and spillway width, cost studies comparing various combinations were conducted. One set of studies evaluated the costs with a broad-crested weir placed between the existing spillway and the Little Dry Creek outlet works. Another set of studies considered an ogee spillway located at the present spillway site. Because the broad-crested weir option would entail considerable excavation for the new entrance and exit channels and the ogee spillway option would not, it became apparent that the latter option was less expensive and was therefore selected.

For an ogee spillway, seven dam-height/spillway-width combinations were considered. These combinations ranged from a dam crest elevation of 441.9 with a 750-foot wide spillway, to a dam crest elevation of 443.5 with a 450-foot wide spillway. A dam crest elevation versus total dam cost curve was developed and the optimum combination was found to be a dam crest elevation of 442.6 and a 550-foot wide spillway. For all cases evaluated, the gross pool-spillway crest elevation was 433.2. The selected spillway width results in a maximum spillway design flood pool elevation of 439.6. The addition of a 3-foot freeboard allowance established the dam crest elevation of 442.6.

b. Outlet Works. - The existing dam has two outlet works. The smaller regulates flows for beneficial use into Dry Creek. The larger regulates flood flows into the Little Dry Creek Diversion channel. The project sponsor expressed a desire that both of these flow routes be retained.

As currently envisioned, future project operation during the flood season will consist of making flood releases through the Little Dry Creek outlet with the capability of also making releases into Dry Creek at the option of the FMFCD, depending on the amount of local runoff experienced below the dam. An open channel to divert flows from the Little Dry to Big Dry outlet was considered as an alternative to replacing the Big Dry Creek outlet works. While this alternative would save the cost of replacing Big Dry Creek outlet works, it was not selected because it could not provide the desired operational flexibility. Flows could not be passed down Dry Creek

during the flood season, nor could they be passed down Little Dry Creek during the nonflood season without providing an operationally complex and costly Little Dry Creek exit structure. Thus, two sets of outlet works will be retained for the proposed project.

Utilizing portions of the existing outlet works for the enlarged project was considered but rejected because the existing structures will have been in place for nearly 50 years by the time the proposed project is scheduled to be constructed and because aspects of the existing outlet works designs do not meet current design criteria. This decision will be evaluated further during Feature Designs. Thus, the intake tower and stilling basin of the existing Big Dry Creek outlet will be removed and a new tower, conduit, and impact basin will be constructed approximately 100 feet southeast of the existing site. The existing conduit will be plugged at both ends and will remain in place. A cost comparison of access bridge and conduit length versus approach channel walls indicated that the most economical design is a 30-foot long approach channel leading to the control tower; the control tower will be inset into the upstream toe of the dam embankment. Because the existing Little Dry outlet works is situated in a cut between two hills, the most economical location for the new outlet works was found to be the location of the existing outlet works, reducing the need for additional excavation. This replacement would include removal of the existing conduit, control tower, and stilling basin. A cost comparison of the access bridge and conduit lengths versus approach channel walls indicated that the most economical design is a 17-foot long approach channel leading to the control tower.

Wet tower and dry tower options were considered for both outlet works. Considering the expected low hydrostatic heads, a wet well tower offers little structural advantage. Differences in costs between the two are negligible. A dry tower provides greater protection for the gate operating equipment and allows maintenance and repair to be accomplished at any time, without regard to reservoir level. Costs can be kept low by providing minimum access to the gate level and portable tools and equipment to carry out maintenance work. Consequently, the Big Dry and Little Dry outlet works towers have been designed as dry well facilities for the project.

15. Fancher Creek Dam. - Two alternative designs of Fancher Creek Dam were evaluated during CP&E studies. Both are based on the plan currently recommended to Congress (Recommended Plan). The principal difference between the two plans is that one alternative has a gated outlet works and the other an ungated outlet works. The ungated outlet works alternative is the Selected Plan, presented in detail in this GDM. It was selected because it requires no operation, requires less maintenance, had a low first and annual cost, and resulted in lower flood control pool elevations. Plans and sections for the two alternative designs are shown on Plates F1, F2, and F5. The major features these designs have in common are: 1) a 16,896-foot long embankment with a section featuring a 25-foot crest width, a broken upstream slope with 1V on 2H from the crest to elevation 490.0 and 1V on 3H below elevation 490.0, and 1V on 2H downstream slopes, 2) an ungated ogee spillway, and 3) a 200-year level of protection, and 4) a new stilling basin and concrete T-beam bridge replacing the existing flip-bucket and bridge at the

end of the overchute. The principal differences between the two alternatives are presented in Table 4.

The principal differences between the Recommended Plan (before Congress) and the two alterantives are shown below:

	Storage Capacity (Acre-feet)	Design Discharges (cfs)	Level of Protection
Recommended Plan (gated)	9,600	200	100
Gated Outlet Works Alternative	10,850	400	200
Ungated Outlet Works Alternative (selected plan)	10,304	100	200

The changes from the Recommended Plan shown above resulted principally from optimizing the flood control system operation plan developed during CP&E studies. The small increase in reservoir size combined with a change in the maximum allowable release resulted in a facility with nearly the same cost as in the Recommended Plan but providing a higher level of downstream protection and thereby benefits. This shifted the most economical level (maximum NED benefits) of protection from 100 year (Recommended Plan) to 200 year (current Selected Plan).

For comparison purposes, the plan recommended by the ASA to Congress features the following: 1) a reservoir storage capacity of 9,600 acre-feet capable of controlling the 100-year design flood event, 2) an uncontrolled 50-foot wide ogee spillway which utilizes the existing 30-foot wide Fancher Creek overchute of the Friant-Kern Canal (Canal Station 1126+60) as part of the exit channel, 3) a gated outlet works consisting of a 2.25-foot wide by 3.25-foot high conduit sized to safely pass a maximum of 200 cfs with reservoir pool at spillway crest elevation, 4) an electrically operated control gate, and 5) embankment slopes of 1V on 3.25H upstream and 1V on 2.5H downstream. A comparison of costs for the Recommended Plan and the Selected Plan is shown in Table 35 of Chapter XV - Cost Estimates.

During development of the two alternatives, various dam height and spillway widths, operational criteria, outlet works, spillway alternatives, and dam alignments were investigated. A summary of these investigations is presented in Table 4.

a. Dam Height Versus Spillway Width Analysis. - In order to determine the optimum dam height and spillway width, cost studies comparing various combinations were conducted. The results of this study for 30, 60, and 90-foot wide spillways are shown in Table 4. Intermediate spillway widths were also considered but data is not presented. A discussion of the freeboard analysis is presented in Chapter V - Hydrology and Hydraulics. A 60-foot wide spillway and corresponding dam embankment were determined to be the least costly alternative for both the gated and ungated outlet works designs and is used in the Selected Plan. As indicated in Table 4, although a 90-foot wide spillway yields a lower embankment first cost (for the same freeboard provision), the relatively high cost of the spillway itself excludes this option from being considered for the Selected Plan. A 90-foot

Table 4

Fancher Creek Dam
Alternative Designs Investigated

Project Data	Gated Outlet Works				Ungated Outlet Works			
SPILLWAY								
Width (Feet)3/	30	60	60	90	30	60	60 1/	90
Wall Shape	T	T	U	T	U	U	U	T
Wing Wall approach	No	No	Yes	No	No	No	Yes	No
RESERVOIR								
Gross Pool El.	481.5	481.5	481.5	481.5	480.5	480.5	480.5	480.5
SDF Pool El.	493.5	491.3	491.3	490.0	492.3	490.3	490.3	489.0
Gross Pool Capacity (Acre-feet)	10,850	10,850	10,850	10,850	9,900	9,900	9,900	9,900
EMBANKMENT								
Crest El.	498.5	496.3	494.3	495.0	495.3	493.3	493.3	492.0
Freeboard (Feet)	5	5	3	5	3	3	3	3
OUTLET WORKS								
Size (Feet)	3x5	3x5	3x5	3x5	3x3	3x3	3x3	3x3
REAL ESTATE REQUIREMENTS								
Fee (Acres)	140	130	130	130	140	127	127	120
Easements (Acres)	965	965	965	965	845	845	845	845
MAJOR COST ITEMS2/								
Main Dam ($\$x10^3$)	16,900	15,600	13,700	14,900	14,700	12,800	12,800	12,700
Spillway and Outlet Works ($\$x10^3$)	2,070	2,390	2,160	3,760	1,460	1,920	1,970	2,890
Friant-Kern Canal Diversion ($\$x10^3$)	0	0	0	540	0	0	0	540
TOTAL PROJECT FIRST COST ($\$x10^3$)	25,600	24,400	23,200	25,200	23,500	21,900	22,000	23,300

1/ Selected Plan
2/ Includes a 25 percent contingency; and based on 1985 price levels.
3/ The 60-foot wide spillway reflects the optimum combination of dam height and spillway crest.

wide spillway requires replacing the existing Friant-Kern Canal overchute with a 90-foot wide exit chute structure. The Friant-Kern Canal would have to be rerouted during construction to insure that the Bureau of Reclamation could meet contractual commitments to deliver irrigation water. Table 4 also shows that between the 30-foot and 60-foot wide spillway options, the design incorporating a 60-foot wide spillway had a lower total project first cost.

b. Operation Criteria. - The system operation criteria upon which the alternative designs were based are: 1) the Fancher gated outlet works and the Mill Ditch Headworks would be operated in such a manner as to allow a maximum flow of 200 cfs in Mill Ditch at Temperance Avenue, assuming a maximum Fancher Creek outlet works discharge of 400 cfs, and 2) flows in Mill Ditch at the Herndon Canal be limited to 500 cfs during a 200-year event assuming a maximum ungated outlet works discharge of 100 cfs.

(1) Gated Outlet Works. - With the gated outlet works, during the 200-year design flood event, the operating criteria require that the gate be closed until the outflow from Redbank Creek Detention Basin into Mill Ditch decreases such that flows in Mill Ditch at Temperance Avenue are below 200 cfs. Consequently, no flood water would be released through the gated outlet works during much of the 200-year and Spillway Design Flood (SDF) events. Hence a greater reservoir storage volume would be required to control these floods. Following flood events, the gated outlet works releases would be higher and the reservoir would be evacuated more quickly than with an ungated outlet works.

(2) Ungated Outlet Works. - With an ungated outlet works, the Fancher Creek Headworks would be closed to Mill Ditch so that flood releases from Fancher Creek Dam would remain in Fancher Creek and be diverted safely out of the project area. The ungated release from the dam to Fancher Creek would be limited to 100 cfs so that this release, combined with local inflow, would not exceed the Fancher Creek channel capacity downstream from the dam, during the 200-year design flood event. Designing the ungated outlet works in accordance with the operating criteria reduces the storage requirements for the 200-year and SDF events because the outlet works will provide continuous releases up to 100 cfs. However, a longer evacuation period is required with an ungated outlet works due to the lower release capacity.

c. Outlet Works Alternatives. - The gated outlet works would be located immediately to the left of the spillway. The conduit would be 3 feet wide and 5 feet high, sized to pass a maximum of 400 cfs with the reservoir pool at spillway crest. Flow through the conduit would be controlled by a surface mounted, electrically operated slide gate. An emergency gate also would be provided. The ungated outlet works would be incorporated into the ogee spillway structure, adjacent to the left spillway abutment. The conduit would be 3 feet wide and 3 feet high, the minimum size for inspection purposes, with a flow restrictor to limit the outflow to 100 cfs at gross pool (spillway crest). The ungated outlet works alternative was selected because of its operational simplicity, lower gross pool, and overall lower total project first cost.

d. Spillway Alternatives. - Based on feasibility studies, the spillway channel design for the Recommended Plan consisted of T-walls and a 12-inch thick center slab. However, the Feasibility Report recommended that a U-wall structure be investigated at a later date. During design of the ungated alternative, a U-framed spillway channel structure was compared to a T-wall with center slab concept. The comparison showed that a U-framed spillway channel is more economical than a T-wall channel. Thus, the selected design includes a U-wall spillway channel.

In addition to investigating alternative spillway channel wall designs, two hydraulically different approach channel shapes were evaluated. They were a straight approach provided either by T-walls or U-walls, and a curved approach channel utilizing 30-foot radius wing walls. The wing wall design was deemed to be hydraulically more efficient than the straight approach channel and was selected, although the selected design costs $60,000 more than the straight wall design.

e. Embankment Alignment. - During the design of Fancher Creek Dam, cost comparison studies were performed on realigning the southern portion of the embankment to include all or a portion of an 80 acre vineyard in the reservoir area. The three dam alignments evaluated are: 1) include 6 acres of vineyard, increasing the dam height by about 1.7 feet over the selected design and requiring a curved spillway configuration to use the existing overchute, 2) include 21 acres of vineyard, increasing the dam height by about 1.2 feet, and 3) include 80 acres of vineyard (the selected design). Alternative 1 would require a hydraulic model study of the curved spillway chute. The cost for the higher embankment and curved spillway of alternative 1 was estimated to be $1.75 million greater than the selected design. Alternative 2 was estimated to cost an additional $800,000 over the selected design. Thus, it was found to be more economical to include all 80 acres of the vineyard in the reservoir, giving the dam alignment as shown on Plate F1 and reflected in the Selected Plan. The location of the vineyard is shown on Plate F28.

A detailed description of the Selected Plan is presented in Chapter IV - Description of the Selected Plan.

16. Pup Creek Detention Basin. - Three alternative designs were developed during CP&E studies for the proposed Pup Creek Detention Basin. These alternatives were based on the plan currently recommended to Congress, the Recommended Plan. The alternatives are the Partially Excavated Basin design, the Excavated Basin Design, and the Modified Feasibility Basin design. The Partially Excavated Basin alternative is the selected design, presented in detail in this GDM. The basin designs were developed to minimize the excavation and embankment costs while providing 200-year flood protection downstream along Pup Creek with a maximum release of 25 cfs. Plans and sections for the three alternatives are shown on Plates P1, P3, and P4. The major features these designs have in common are: 1) a 495 acre-foot storage capacity, and 2) retention embankments. The significant differences among the alternatives are presented in Table 5. For comparison purposes, a description of the Recommended Plan is presented below. A comparison of the costs for the Recommended Plan and the Selected Plan is shown in Table 35 of Chapter XV - Cost Estimates.

Table 5

Pup Creek Detention Basin
Alternative Designs Investigated

Project Data	Partially Excavated Basin 1/	Excavated Basin	Modified Feasibility Design
BASIN			
Type	Excavated Embankment	Excavated Embankment	Embankment Contained
BDF Pool El.4/	376.8	373.5	383.8
SDF Pool El.	No spillway	No Spillway	388.4
Basin Invert El.	366.0	361.0	375.0
EMBANKMENT			
Maximum height (feet)	19.4	3	2
Length (Feet)	710	230	12,900
Crest El.	376.8	373.5	391.4
OUTLET WORKS			
Type	Ungated RCP	Ungated RCP	Gated RCP
Diameter (Inches)	36	36	36
Energy Dissipation	Impact Basin	Scour Hole	Scour Hole
EXIT CHANNEL			
Type	Open/Piped	Open Channel	Open Channel
Length (Feet)	640/2,320	8,100	
REAL ESTATE REQUIREMENT			
Easements (Acres)3/	64	65	365
TOTAL PROJECT FIRST COST(x10^3$)2/	5,310	6,780	18,000

1/ Selected design.
2/ Includes a 25 percent contingency; based on 1985 price levels.
3/ Fee acquisition requirements are the same for all three alternatives.
4/ Basin Design Flood (200-year).

Alternative Designs Investigated

a. Recommended Plan. - The Pup Creek Detention Basin design presented in the Feasibility Report and recommended to Congress features the following: 1) a 280 acre-foot detention basin, 2) approximately one mile of retention embankment with a maximum height of 17.0 feet designed to contain a 200-year design flood event without spillway discharge, 3) a 150-foot wide broadcrested uncontrolled spillway, and 4) an outlet works consisting of a U-wall intake structure, a 36-inch diameter reinforced concrete pipe, a power operated slide gate which would control the discharge to 25 cfs, and an impact-type energy dissipator.

b. Modified Feasibility Basin Design. - The hydrologic data and the refined operation studies available after the feasibility studies were completed indicated a requirement for an increase in the flood control storage space from 280 acre-feet to 495 acre-feet. The Modified Feasibility Basin design reflects this change. Approximately 12,900 feet of retention embankment would be needed to create the required storage volume of 495 acre-feet. The embankment would consist of impervious fill materials with a maximum height of 19.4 feet. The embankment would contain a 270-foot wide broadcrested, concrete-lined, uncontrolled spillway discharging to Pup Creek, with the crest elevation set to contain the 200-year design flood without overflow. The outlet works would consist of a U-wall approach structure and 36-inch diameter reinforced concrete pipe conduit. Flows would be controlled by a power operated slide gate and discharge to a concrete impact-type energy dissipator. A maximum discharge of 25 cfs would be retained.

c. Excavated and Partially Excavated Basin Designs. - During the Feasibility Study the Fresno County Board of Supervisors established 230 acres of Open or "O"-zoned area for the Pup Creek Detention Basin. This area was subsequently reduced during CP&E studies to 89 acres. This decrease necessitated a change in the design of the basin so that it would be capable of storing 495 acre-feet within the reduced "O"-zoned area. Excavation versus embankment cost comparison studies were conducted to identify the least costly combination of excavation and embankment for the 495 acre-foot storage requirement. The Excavated and Partially Excavated Basin alternatives were derived from these studies.

(1) Excavated Basin Design. - The Excavated Basin design requires excavation of the entire "O"-zone area to a basin invert elevation of 361.0 and constructing a retention embankment along a portion of the basin perimeter to retain the 200-year design event water surface elevation of 373.5, a maximum of 2 feet above natural ground. The embankment would consist of impervious material capped with a soil cement layer for erosion protection, described in Chapter VI - Geology and Construction Materials. The embankment would be designed for overtopping from floods greater than the 200-year design event. No spillway would be necessary.

(2) Partially Excavated Basin Design. - An analysis of the cost of the Excavated Basin showed that excavation and real estate requirements were the major cost items. Consequently, a design was developed to lower excavation requirements without requiring additional lands outside of the "O"-zone boundary. By raising the basin invert 5 feet from elevation 361.0 to 366.0 and providing a 3-foot maximum height retention embankment along a

portion of the basin perimeter, basin excavation could be substantially reduced while retaining the required storage. The embankment would be designed for overtopping from floods greater than the 200-Year design event, as with the Excavated Basin Design. The embankment would be constructed from excavated material and protected from erosion by a layer of soil cement. No spillway would be provided.

After the designs for the detention basin were completed, the FMFCD requested that the inside basin side slopes be flattened from the Corps recommendation of 1V on 4H to 1V on 8H. Without raising the embankment height this would result in either a reduction in storage capacity or a drop in the basin invert. However, the latest available detailed topographical surveys of the site, received subsequent to the initial CP&E work, showed that the 495 acre-foot required storage volume could be achieved with 1V on 8H side slopes and 3-foot high retention embankment while retaining the invert at elevation 366.0.

d. Evaluation of Alternative Basin Designs. - The Selected Plan features a partially embankment contained and partially excavated basin. This type of basin is more cost effective than a completely embankment contained or a completely excavated basin; it is the optimum combination of excavation and embankment. The Modified Feasibility Basin featured a spillway which contributed to the high first cost of $18 million, shown in Table 5. The large amount of excavation required for the Excavated Basin makes this more costly than the Selected Plan. The first cost of the Excavated Basin is about $1.5 million more than the first cost of the Selected Plan as shown on Table 5.

e. Alternative Outlet Works. - During development of the three alternative basin designs, various types of outlet works were investigated. They included pumping the water out of the basin and a variety of ungated, gravity flow, piped options. They were designed to discharge a maximum of 25 cfs, which is the safe capacity of the existing Pup Creek system of open channels, culverts, and pipes.

(1) Pumped Flow. - This option features three 3,800-gpm electric pumps to evacuate water from the basin to Pup Creek. Two pumps are sufficient to discharge 25 cfs from the basin, the third is for stand-by use. The water would be pumped into an impact basin. This option included a 51-inch diameter reinforced concrete pipe for supplemental gravity discharge of storage above elevation 370.0. The pumped flow outlet works is shown on Plate P5.

(2) Conduit. - Three sizes of outlet works conduits were investigated: a single 51-inch and twin 40-inch diameter reinforced concrete pipes and a 36-inch diameter pipe, which is the smallest allowed for inspection purposes. Flow would be directed into the conduit by a "U"-wall shaped intake structure and controlled by a restrictor plate so that the maximum 25 cfs outflow would occur at gross pool. This flow will be released to a preformed scour hole. Piped flow outlet works alternatives are shown on Plate P1 and P5.

f. Evaluation of Alternative Outlet Works. - The first costs for the conduit type outlet works were $15,900, $16,900, and $19,500 for the 36-inch, 51-inch, and twin 40-inch diameter conduits, respectively. The annual operation and maintenance costs for each of the three systems was approximately $1,900. Because the pumped-flow type outlet works is an operated system the annual operation and maintenance cost is much higher than for an ungated conduit-type outlet works. The estimated annual operation and maintenance cost for the pumped flow outlet works is $17,000 (October 85 price level). This cost includes servicing the pumps, operation (including cost of power), and maintenance and replacement of structural and electrical equipment. Based on cost, the single 36-inch diameter pipe alternative was selected.

g. Alternative Exit Channels. - During development of the basin design, four types of exit channels were investigated: existing channel, modified-open, piped, and a combined open and piped channel. Various exit channel lengths dependent on the invert slope, invert elevation of the outlet works, and compatability with the City of Clovis' storm drain system were considered. The exit channels were designed to carry at least the maximum basin discharge of 25 cfs.

(1) Existing Channel. - The existing Pup Creek channel could be used as an exit channel for the pumped outlet works and for a piped outlet works with the Modified Feasibility Basin alternative. Other basin and outlet works options require the invert of the exit channel to be below the invert elevation of the existing channel. Thus, the existing channel was not incorporated into the Selected Plan.

(2) Modified Open Channel. - The modified open channel would be formed from the existing channel and would have a trapezoidal shape with a 10-foot bottom width, and 1V on 2H side slopes for ease of construction and maintenance. Various exit channel lengths and depths were considered, based on assumptions of where the City of Clovis' storm drain system along Pup Creek will end, the storm drain pipe invert elevation, the channel slope, invert of the outlet works, and the location of the outlet works along the perimeter of the basin. For example, one set of assumptions examined during CP&E studies resulted in an 8,000-foot long modified channel extending from the southwest corner of the basin to Fowler Avenue with an invert slope of 0.0005, outlet works invert elevation of 361.0 and a 14-foot maximum depth. A 3,000-foot long channel was examined using another set of assumptions. This channel would be located about 500 feet north of the southwest corner of the basin, with an invert slope of 0.0003, outlet works invert elevation of 366.0, and a 10-foot maximum depth.

(3) Piped Exit Channel. - Various sizes of pipes could be used for the exit channel including a 51-inch, 40-inch, and a 36-inch diameter size that would be compatible with the outlet works conduit options. As with the modified open channel, various pipe lengths were considered for a piped exit channel based on assumptions regarding compatability with the storm drain system, slope of the pipe, and outlet works and invert elevations. For example, a 3,200-foot long piped exit channel having the same alignment as the existing channel was considered for the twin 40-inch diameter conduit

outlet works. This pipe had the same invert slope as the 8,000-foot long open channel described above, and a capacity of 35 cfs.

(4) Combination Open/Piped Channel. - The combined open and piped channel system featured an open channel from the outlet works to Temperance Avenue followed by a piped system from Temperance Avenue to the end of the local storm drain system. Two sizes of conduits were considered for the piped portion of this exit channel: Twin 36-inch and a single 48-inch diameter reinforced concrete pipe, based on a desire of the local sponsor to have the exit channel compatible with the storm drain system. The storm drain system has a 40 cfs capacity, 25 cfs for basin outflow and 15 cfs (10-year storm) for local inflow.

h. Evaluation of Alternative Exit Channels. - The first costs for the exit channels were $216,000, $508,000, and $372,000 for a modified open (3,200-ft), piped (3,200-ft), and combined open/piped (2,960-ft), respectively. Annual operation and maintenance cost is $150 for both the open exit channel and the combined open/piped exit channel because the majority of the sediment is expected to settle out in the first 640 feet of the exit channel. Due to the very small expected sediment deposition in the piped exit channel the maintenance costs will be negligible. The combined exit channel was chosen to allow for control of local flood flows between the basin and Temperance Avenue with the open-channel portion, and to provide compatability with the storm drain system, desired by the local interests by using the piped portion.

17. Alluvial Drain Detention Basin. - Three alternative designs were developed during CP&E studies for the proposed Alluvial Drain Detention Basin. They are based on the plan currently recommended to Congress (Recommended Plan). The alternatives are the Selected Plan, Excavated Basin, and the Modified Feasibility Basin design. The selected design is presented in detail in this GDM. The alternatives were developed to minimize excavation costs for the necessary storage requirement. The plans and sections for these alternative designs are shown on Plates A1, A3, and A4. A comparison of costs for the Recommended Plan and the Selected Plan is shown in Table 35 of Chapter XV - Cost Estimates.

The major features these designs have in common are: 1) a 385 acre-foot storage requirement, and 2) a 36-inch diameter conduit outlet works with a U-wall approach structure. The significant differences among the plans are presented in Table 6. The alternative designs were developed to provide 200-year design flood protection to areas downstream of the detention basin with a maximum release of 25 cfs. For comparison purposes, a description of the Recommended Plan is presented below.

a. Recommended Plan. - The plan recommended to Congress features the following: 1) a 225 acre-foot detention basin, 2) approximately 7,920 feet of retention embankment with a maximum height of 14.6 feet, 3) a 160-foot wide broad-crested uncontrolled spillway with crest elevation set to contain the 200-year design flood event without discharge, and 4) an outlet works consisting of a U-wall intake structure, a 36-inch diameter reinforced

Table 6

Alluvial Drain Detention Basin
Alternative Designs Investigated

Project Data	Modified Feasibility Design	Excavated Basin	Selected 1/ Plan
LAND REQUIRED			
Fee (Acres)	16.4	6	3
Easement (Acres)	295	57	57
RETENTION EMBANKMENT		None	None
Maximum height (Feet)	16.2		
Crest width (Feet)	10		
Crest length (Feet)	8,976		
DETENTION BASIN			
Invert elevation (Feet)	Original ground	375.0	377.9
378.0			
Cut slopes		1V on 8H	1V on 8H
Excavation required (C.Y.)	None	863,700	685,900
Gross Pool Elevation	392.1	384.2	386.4
Storage-Requirement (AF)	385	385	385
Storage-Max. Capacity (AF)	385	410	385
SPILLWAY			
Type	Uncontrolled Broadcrest	None	None
Width (Feet)	260.0		
SPF Pool Elevation	395.2		
OUTLET WORKS			
Invert elevation (Feet)	384.0	375.0	377.9
Conduit Length (Feet)	140	125	112
Release control	36" diameter slide gate	Steel plate flow restrictor	Steel plate flow restrictor
Energy dissipator (Type)	Concrete impact basin	Preformed Scour hole	Preformed Scour hole
EXIT CHANNEL	None		
Channel length (Feet)		5,000	2,000
Invert slope		0.0003	0.0003
Cut slopes		1V on 2H	1V on 2H
Bottom Width (Feet)		5	5
TOTAL PROJECT			
FIRST COST ($\$x10^3$) 2/	13,500	4,880	4,030

1/ Selected design
2/ Includes a 25 percent contingency; based on 1985 price levels.

concrete pipe, a power operated slide gate controlling releases to a maximum of 25 cfs, and an impact type energy dissipator.

b. Modified Feasibility Basin Design. - The hydrologic data and refined operation studies available after the feasibility studies were completed required an increase in the flood control storage space from 225 acre-feet to 385 acre-feet. The Modified Feasibility Basin design reflects this change. Approximately 8,976 feet of retention embankment would be needed to create the required storage volume of 385 acre-feet. The embankment would consist of impervious fill material with a maximum height of 16.2 feet. The embankment would contain a 260-foot wide broad-crested, uncontrolled spillway discharging to Alluvial Drain with crest elevation at 392.1, set to contain the 200-year design flood without overflow. The outlet works would consist of a U-wall approach channel and a 36-inch diameter reinforced concrete pipe conduit. Flows would be controlled by a power operated slide gate and discharge to a concrete impact-type energy dissipator. A maximum discharge of 25 cfs would be retained.

c. Excavated Basin. - During the Feasibility Study the Fresno County Board of Supervisors established 145 acres of Open or "O"-zoned area for the Alluvial Drain Detention Basin. This area was subsequently reduced to 57 acres during CP&E studies. This decrease necessitated a change in the design of the basin so that it would be capable of storing 385 acre-feet within the reduced "O"-zoned area. The resulting design was the Excavated Basin B, with an invert elevation 375.0. Features of the design are shown on Plate A4. This design features excavation of the basin to an invert elevation of 375.0. The outlet works would consist of a U-wall intake structure and a 36-inch diameter conduit. The outlet works would discharge a maximum of 25 cfs at gross pool to a preformed scour hole. The existing channel would be modified to contain the regulated design flood flows. The exit channel would be 5,000 feet long, trapezoidal shaped with 1V on 2H side slopes, a 5-foot bottom width, and a 0.0003 slope.

d. Selected Plan. - As with Pup Creek Detention Basin, an analysis of the cost of the excavated basin showed excavation and real estate requirements were the major cost items. Thus, a third basin was developed to lower excavation requirements without incurring additional costs. Prior to the development of this basin design, detailed information regarding land development upstream of the basin was made available. This information revealed that the water surface elevation just upstream of the basin, at the development site, is 390.4 not 386.4 as was established previously. The raised water surface elevation resulted from recontouring the land as part of the development. Based on this information, a basin with an invert elevation of 378.0 was designed. This design allowed the basin invert to be raised 3 feet from elevation 375.0 to 378.0 without changes in inflow flood hydrograph, hence, the storage requirement remained at 385.0 acre-feet. This design also assured that the upstream water surface elevation in the development is preserved. With this change in invert elevation, the outlet works was retained from excavated Basin B but the exit channel was shortened to 2,000 feet. Features of this plan are shown on Plate A-1.

e. Plan Evaluation. - Table 6 shows that the Selected Plan is the least costly alternative. This alternative was identified as the selected design. It costs $850,000 less than the Excavated Basin and $9,470,000 less than the Modified Feasibility Design. A detailed description of this alternative is presented in Chapter IV - Description of the Selected Plan.

18. Redbank Creek Detention Basin. - Two alternative designs were developed during CP&E studies for the proposed Redbank Creek Detention Basin. These alternatives were based on the plan currently recommended to Congress, the Recommended Plan. One alternative has a gated control structure and the other an ungated control structure. The gated design is the selected design, presented in detail in this GDM. The basin design was developed to minimize excavation costs while not exceeding a given maximum allowable outflow.

The major features the Recommended and alternative designs have in common are: 1) the capacity to release a maximum of 200 cfs for a 200-year or less design flood event, 2) a control structure across Redbank Creek, and 3) excavated storage. The basin is designed to control a 200-year design flood event on Redbank and Dog creeks for the area below Temperance and McKinley avenues. The significant differences among the three designs are shown in Table 7 and their plans and sections are shown on Plates R1, R4, and R5.

a. Recommended Plan. - The basin designed for the Feasibility Study would store 1,650 acre-feet of water in two excavated basins. The basins would be separated by Mill Ditch which flows from east to west through the site, joining Redbank Creek at the western boundary of the proposed basin. Four 6-foot diameter reinforced concrete inverted siphons under Mill Ditch would allow water to pass between the two basins. All cuts and fills would have 1V on 2H side slopes. Plans and sections are shown on Plate R4.

(1) North Basin. - The north basin would be completely excavated, have a storage capacity of 550 acre-feet and be equipped with a 50-foot long broad-crested inlet weir to retain flows less than 200 cfs in Redbank Creek. Two 36-inch diameter conduits with manually operated gates would allow stored water to be released to Mill Ditch. Releases to Redbank Creek from the basin would be controlled by two power driven slide gates mounted on a buttressed headwall located in Redbank Creek approximately 3,700 feet upstream from Temperance Avenue. The top of the control structure would be set at an elevation of 352.0. Because the elevation of the north bank of Redbank Creek is below elevation 352.0, an embankment would be constructed to tie the basin and headworks to natural ground at elevation 352.0. This embankment section would have a maximum height of 5.0 feet, a length of 1,300 feet, and side slopes of 1V on 2H.

(2) South Basin. - The south basin would be provided with 7,600 feet of earth embankment to store 1,100 acre-feet of water to elevation 350.0. The maximum height of the embankment would be 7.0 feet. Three 36-inch diameter conduits with manually operated gates would allow for releases of stored water from the south basin to Mill Ditch.

b. Ungated Control Structure. - The ungated control structure alternative consists of a single 1,600 acre-foot excavated flood storage

Alternative Designs Investigated

Table 7

Redbank Creek Detention Basin
Alternative Designs Investigated

Project Data	Feasibility Study	Ungated Control Structure	Gated Control Structure 1/
BASIN			
Design Event	200 yr. flood	200 yr. flood	200 yr. flood
Storage Required (Ac-ft)	1,650	1,600	940
Side Slopes	1V on 2H	1V on 8H	1V on 8H
INLET STRUCTURE			
Type	50' Broad-crest Weir	200' Broad-crest Weir	None
OUTLET CONDUITS			
Number	5	5	See Control Structure
Size	36"	36"	
CONTROL STRUCTURE			
Type	Buttressed Headwall	Buttressed Headwall	U-Wall
Gates	2-Power slide gates	0	2-Automatic, buoyancy controlled
BASIN RELEASE (cfs)	200 Regulated	200 Maximum	200 Maximum
EMBANKMENTS			
North of Redbank Cr.			
Max Crest Elev.	352.0	350.0	349.3
Top Width (Feet)	10	15	10
Slopes	1V on 2H	1V on 2H	1V on 2H
Length (Feet)	1,300	2,100	1,900
Max Height (Feet)	5.0	2.8	2.9
Around Basin			
Crest Elev.	352.0	349.0	349.3
Top Width (Feet)	10	10	10
Upstream Slope	1V on 2H	1V on 8H	1V on 8H
Downstream Slope	1V on 2H	1V on 2H	1V on 2H
Length (Feet)	7,600	2,750	2,800
Max Height (Feet)	7.0	4.0	3.0
MILL DITCH	Existing	Rerouted	Rerouted
UNCLASSIFIED EXCAVATION (cy)	2,806,200	3,332,000	2,110,000
TOTAL PROJECT FIRST COST (x10^3$) 2/	19,400	24,400	14,200

1/ Selected design
2/ Includes a 25 percent contingency; based on 1985 price levels.

basin with a retention embankment along the north bank of Redbank Creek and three retention embankments along the south and west ends of the basin. With this design, Mill Ditch would be rerouted around the southern perimeter of the basin, as recommended during the April 1982 General Design Conference. The rerouted channel would have a 12-foot bottom width, 1V on 3H side slopes, and erosion protection at the channel bends. The design flow is 1,300 cfs, based on maximum irrigation requirements during the non-flood season. Flows at the basin would be controlled by an inlet weir, 4 culverts through the weir, an ungated control structure, and an outlet works.

The basin would be equipped with a 200-foot long broad-crested inlet weir. Four 36-inch diameter, flap gated, reinforced concrete culverts would pass through the inlet weir to serve as outlet works, releasing stored water back into Redbank Creek once flood flows have subsided downstream. The weir crest would be at elevation 345.9 and the invert of the flap gated culverts would be at elevation 335.5. The buttressed, ungated control structure would be placed about 350 feet downstream from the weir in the existing Mill Ditch. The control structure would control flows in Redbank Creek until the water rises to the inlet weir crest elevation of 345.9 and passes into the basin. The top of the concrete control structure wall would be set at elevation 349.0. Floods greater than the 200-year design event would overtop the structure. However, the control structure would be expected to suffer only minor damage. An outlet works facility would be located in the western most portion of the basin. It would consist of a single 36-inch diameter, manually operated, gated conduit. This structure would allow drainage of water from the bottom of the basin to Redbank Creek. Evacuation time following the design flood would be approximately 14 days.

The retention embankment along Redbank Creek would have a crest width of 15 feet and crest elevation of 350.0. This crest elevation would provide 1-foot of freeboard above the maximum design water surface. Embankment slopes would be 1V on 2H and a maximum of 2.8 feet high. The three additional retention embankments would have a 10-foot crest width and a crest elevation of 349.0, coincident with the design flood event maximum water surface elevation, 1V on 2H side slopes, and a maximum height of 4.0 feet. The purpose of different embankment crest elevations is to force any flows greater than the 200-year design event to spill into Mill Ditch which would carry them out of the area, reducing the potential for damage in the vicinity of the basin.

c. Gated Control Structure. - To reduce the required excavation and thus cost, use of available channel capacity was optimized with a gated control structure designed to retain water in the basin while controlling outflow to automatically maintain a constant downstream water surface elevation. Two self-regulating, buoyancy activitated, gates would be mounted in the control structure constructed in Redbank Creek approximately 2,000 feet upstream from Temperance Avenue. The gates would be set to control outflow so that downstream water surface elevations are at or below elevation 338.5, which corresponds to 200 cfs in Mill Ditch at Temperance Avenue.

As with the ungated control structure design, the basin would be a single partially excavated-partially embankment contained facility. The 940

acre-foot basin would be excavated to elevation 342.2. The side slopes would be 1V on 8H, serving to increase the seepage path between the detention basin and the rerouted Mill Ditch and, as for Pup Creek and Alluvial Drain Detention Basin, provide for multiple use of the basin by the Local Sponsor during the non-flood season. The 1,450-foot long southern portion of the creek bank that is contained within the basin acts as an inlet weir section to the basin. An embankment would be constructed on the north bank of Redbank Creek. It would have 1V on 2H side slopes and a crest width of 10.0 feet. Three other embankments would be constructed around the south and west ends of the basin. They would have 1V on 8H inside slopes and 1V on 2H outside slopes. All embankments would be protected from erosive damage resulting from overtopping, due to a flood greater than the 200-year design event, by protecting the crest, downstream slope, and apron with a soil cement cap. The soil cement sections are described in Chapter VI - Geology and Construction Materials. No freeboard allowance and no spillway will be provided. The embankments will have a maximum height of 3.0 feet and will retain water up to elevation 349.3. Evacuation time at the end of the 30-day design flood routing is less than one day.

As with the ungated headworks design, Mill Ditch would be rerouted along the southern perimeter of the basin. It would have a 12-foot bottom width and 1V on 3H side slopes. Erosion protection would be provided on the outside of all bends. The confluence of the rerouted Mill Ditch and Redbank Creek will be similarly protected.

d. Plan Evaluation. - The cost of constructing the Ungated Control Structure design is estimated to be $5.0 million more than the Recommended Plan. Although the embankments are lower for the ungated control structure plan than for the Recommended Plan, excavation was the major cost factor, making this alternative more costly than the Recommended Plan. Thus, the ungated control structure design was not considered further.

The estimated cost of construction of the gated control stucture plan is $1.1 million less than the Recommended Plan and $6.1 million less than the ungated control structure plan. Thus, because of its relatively simple operation, shorter evacuation time, and lower construction costs, the gated control structure design is the Selected Plan. A detailed description of this alternative is presented in Chapter IV - Description of the Selected Plan.

19. Introduction. - The plan recommended to Congress for protecting the Fresno-Clovis Metropolitan area and adjacent rural areas from flooding consists of raising Big Dry Creek Dam and constructing a new dam and three detention basins. These five project features are designed to be integrated into the comprehensive flood control system for Fresno County. The completed project facilities will be turned over to the Fresno Metropolitan Flood Control District (FMFCD) for operation and maintenance, described in Chapter XIV - Operation, Maintenance, and Inspection of Completed Work. The project features will be operated as a system in accordance with the procedures specified in Chapter XIII - System Operation, and the Reservoir Operation Manual which will be completed before the end of project construction. Plate G7 shows the interrelationship of the project features. A detailed description of the Selected Plan is presented below.

20. Big Dry Creek Dam. - The existing Big Dry Creek Dam, on Dry Creek, will be raised from elevation 435.0 to elevation 442.6 to increase the storage capacity from the present 16,500 acre-feet to 31,785 acre-feet, at gross pool. The resulting level of flood protection will be increased from the current 60-year frequency to Standard Project Flood (SPF) protection. The existing Dog Creek diversion embankment and outlet structure above the Friant-Kern Canal will be retained essentially as is to divert flows into Big Dry Creek Reservoir. The Dry Creek crossing of the Friant-Kern Canal, Dry Creek embankment above the Friant-Kern Canal, and canal levees will be modified to insure passage of the SPF into the reservoir. Along with raising the dam, the two existing outlet works and the spillway will be replaced. The proposed operation of the enlarged Big Dry Creek Dam and Reservoir will be essentially the same as the current operation; the controlled flood flows will continue to be diverted to the San Joaquin River via the Little Dry Creek Diversion channel. The plan for the enlarged dam and reservoir with associated design details are shown on Plates B1 thru B6.

a. Embankment. -

(1) Alignment. - The embankment alignment closely parallels the existing embankment. The centerline of the new embankment will be offset 16 feet upstream of the centerline of the existing embankment for the section which parallels Shepherd Avenue, and coincident with the centerline of the existing embankment for the remaining portion.

(2) Typical Sections. - The existing Big Dry Creek Dam embankment will be incorporated into the new dam section. Typical embankment sections for the enlarged Big Dry Creek Dam are shown on Plate B1. These sections conform to the applicable criteria contained in EM 1110-2-2300 (Earth and Rock-Fill Dams, General Design and Construction Considerations), and EM 1110-2-1902 (Stability of Earth and Rock-Fill Dams).

General features of the section include a 25-foot crest width, 3 feet of freeboard, and broken embankment slopes. The broken slopes optimize the use of available borrow and minimize fill requirements without decreasing overall slope stability. Slopes descend 1V on 2H from the crest to elevation 438.5,

then flatten to 1V on 3H on the upstream side of the dam. This relatively flat slope is the maximum slope easily accessible by maintenance equipment. The lower portion of the downstream slope will be 1V on 2.25H.

During Feature Design Memorandum (FDM) studies, ease of construction and embankment stability will be evaluated in conjunction with the use of random fill materials derived from Pup Creek and Alluvial Drain excavations. If stability calculations permit, downstream slopes will be steepened to 1V on 2H. Fill placement east of DeWolf Avenue will be limited to the crest and upstream slopes. If flatter slopes are required, the existing embankment section east of DeWolf Avenue will be cut to grade, and additional fill placement initiated at the crest of the revised section. The centerline of the expanded section west of DeWolf Avenue will be coincidental with the existing centerline. Because of the low residual pool, short detention times, ease of construction and potential economic savings, the drainage detail also will be revised during FDM work. The drainage detail is expected to be eliminated along Shepard Avenue and reduced to a horizontal section along remaining reaches.

(3) Seepage Control. - Seepage control features include an upstream partial cutoff and inspection trench, and a downstream inclined/horizontal drain. The inspection trench will be excavated to the bottom of surficial pervious alluvium. It will have a bottom width of 20 feet and side slopes of 1V on 1.5H. The trench will extend from Station 35+00 to Station 193+50. The downstream drain is designed to control any seepage through the dam and to intercept any near surface seepage which bypasses the inspection trench. This drain will extend from Station 90+00 to Station 193+00. Typical sections of the drain are shown on Plate B1. The 3-foot thick drain will be constructed of gravel and will be protected by a 12-inch layer of filter material. Commercial sources will be used to supply the gravel drainage fill. Recent alluvial deposits located along Dry Creek will provide filter material. Processing of these deposits will not be required.

(4) Slope Protection. - Based upon the analysis described in Chapter VI - Geology and Construction Materials, considering 37 years of satisfactory operational performance of existing Big Dry Creek Dam, duration of exposure, and other factors, the following slope protection provisions are proposed for Big Dry Creek Dam.

The upstream and downstream slopes will be protected with a combination of turf and erosion resistant clayey sand (SC) random fill. Additional crest protection will be provided by a ten-foot horizontal width section of sandy clay (CL) extending from elevation 437.4 to the dam crest. Material for this section will be obtained from the Fancher Creek Dam borrow area. Transportation of this material will be coordinated with proposed hauling of filter material from the Big Dry Creek Dam site to the Fancher Creek Dam site.

Support for this slope protection design can be found in the 37 year successful operational performance of the existing Big Dry Creek Dam. Because operational procedures will not change and the embankment slopes of the enlarged dam are flatter than those of the existing dam, it appears that the enlarged dam will resist erosion better than the existing dam. If the

upstream slope was to suffer minor benching or erosional damage, the flat slopes will allow easy access for maintenance during dry summer months.

(5) Excavation and Fill Quantities. - Required excavation and fill quantities are shown on Plate B41 along with shrinkage and bulking factors. Embankment fill quantities are summarized in Table 8.

b. Spillway. - The existing spillway is located approximately 2,300 feet northeast of the existing Little Dry Creek outlet. It consists of a 450-foot wide excavated channel incorporating a 10-foot wide broadcrested concrete control sill. The new 550-foot wide ogee spillway section will be constructed at the same location, starting from the present north abutment and extending about 100-feet into the south abutment. Excavation on the south side of the approach and exit channels will be required to accommodate the new spillway width. The spillway plan and details are shown on Plate B6. The spillway discharge rating curve and the spillway design flood routing are shown on Plates B7 and B8.

Table 8

Embankment Fill Quantities
Big Dry Creek Dam

Embankment Fill Zone	Material Source	Material Type	Required Fill (Cy)
Slope Protection	Fancher Borrow Area	Slope Protection	40,100
Filter	Big Dry Creek Borrow Area	Filter Sand	34,000
Random Fill	Big Dry Creek	Random Fill	1,108,100
Random Fill	Existing Embankment Removal	Random Fill	38,000
Random Fill	Inspection Trench Excavation	Random Fill	152,000
Drain	Commercial	Drainage Fill	39,900
Service Road	Commercial	SABC	5,000
Slope Protection	Commercial	Stone	3,000

(1) Approach Channel. - The spillway approach channel will be improved to a trapezoidal shape with a width of 560 feet at the spillway crest elevation of 433.2. Side slopes will be excavated at a 1V on 2H slope

and the resulting bottom width at the existing invert elevation of 424.0 will be 523.2 feet. Concrete abutment walls with radii of 15 feet will provide the transition from the trapezoidal approach channel to the rectangular spillway section. The left side of the approach channel will be excavated so as to maintain a bottom width of 523.2 feet and meet the existing channel invert elevation. The approach channel is shown on Plate B6.

(2) Ogee Crest. - The upstream face of the new ogee section will coincide with the upstream edge of the existing broadcrest sill. The existing sill will be removed. The new spillway crest elevation was set at the design SPF pool elevation of 433.2. The maximum Spillway Design Flood (SDF) inflow is 45,400 cfs and the resulting maximum spillway discharge will be 33,400 cfs. The maximum SDF pool elevation will be 439.6. The ogee crest is designed for a head of 6.4 feet and will terminate on a slope of 1V on 0.8H. A toe radius of 15 feet will provide a transition from the ogee crest to the stilling basin apron.

(3) Stilling Basin. - The basin will be 31.0 feet long and 550 feet wide with an apron elevation of 419.9 feet. Two rows of baffle blocks will be provided. Baffle block height, width, and spacing are set at 1.75 feet. The upstream face of the first row of baffles will be set at 15.5 feet from the start of the basin. The second row of baffles will be placed approximately 5.2 feet downstream of the first row. The stilling basin walls have 3.0 feet of freeboard allowance. The end sill will be 0.85 feet high. The adverse channel slope downstream of the end sill will be initiated at 0.85 feet below the elevation of the end sill.

(4) Exit Channel. - The exit channel will be widened to 560 feet from the stilling basin end sill downstream 550 feet. From a point 550 feet downstream from the end sill, the spillway exit channel will narrow using a 1 on 10 convergence from each side until the toe of cut for the new exit channel matches the toe of cut for the existing exit channel. The exit channel will have an adverse slope of 1V on 10H for approximately 24 feet from the downstream end of the stilling basin end sill to where it intersects the 422.3-foot elevation contour. The next 550 feet of exit channel will have a 0.001 slope and will intersect the existing spillway exit channel. Exit channel velocities will range from 6 to 12 fps. To insure that the required tailwater for proper stilling basin performance will be developed and retained over time, a concrete grade-control sill will be constructed in the invert of the exit channel 500 feet downstream from the ogee crest. The sill will extend a maximum of 20 feet below the channel invert, or to bed-rock, whichever is less. Riprap from the stilling basin end sill to the adverse channel section will be provided on the bottom and side slopes. Beyond the exit channel, spillway discharges will be retained and directed by the natural topography. The proposed spillway modifications will not alter flow paths in this area over that which would be experienced with the existing spillway.

c. Outlet Works. -- The existing Big Dry Creek Dam has two outlet works. The smaller controls flows into Dry Creek which passes through the City of Clovis to the Herndon Canal. The larger outlet controls flows into the Little Dry Creek Diversion channel which runs northwest from the dam

approximately five miles to Little Dry Creek and then to the San Joaquin River.

Project operation during the flood season will remain the same. It will consist of making all controlled flood releases through the Little Dry Creek outlet. However, the capability will exist to make releases to Dry Creek. The releases into Dry Creek will be made at the option of the FMFCD, depending on the downstream requirements or demands which need to be satisfied. During the nonflood season, all releases will be made through Big Dry Creek outlet.

Structurally, the existing outlet work conduits were found to be marginally acceptable, considering the increased embankment height. However, the as-built rebar cover dimensions, in many areas, do not meet current Corps standards. Based on these considerations and the fact that the control towers would have to be significantly modified to accept the current gate configuration, a decision was made to replace both outlet works facilities. This decision will be verified during FDM studies.

(1) Big Dry Creek Outlet Works. - The new tower, conduit, and impact basin will be constructed approximately 100 feet southeast of the existing facility, at Dam Station 174+80. A new outlet channel will merge with the existing one approximately 1,000 feet downstream of the present stilling basin. To decrease demolition and removal costs, the existing Big Dry Creek conduit will be abandoned in place; both ends will be plugged with concrete.

The 3-foot by 3-foot outlet works conduit was sized based on the minimum acceptable dimensions for inspection purposes. It has a discharge capability of 150 cfs at pool elevation 415.0. To restrict discharge to a maximum of 150 cfs at higher pool elevations, gate operation will be required. The Big Dry Creek outlet works plan and details are shown on Plates B2 and B3.

(a) Approach and Intake. - The approach channel for the Big Dry Creek outlet works will be 31.2 feet long, extending from the upstream toe of the embankment to the control tower inlet. The invert of both the approach channel and the tower inlet will be set at elevation 400.0. Elliptical side wall and roof curves will be provided at the intake. The side wall curves have an x-dimension of 1.0 times and a y-dimension of 0.33 times the gate passage width of 3.0 feet. The elliptical roof curve will have an x-dimension of 1.0 times and a y-dimension of 0.67 times the gate passage height of 3.0 feet. The trash rack at the inlet will be 5 feet wide by 6.0 feet high with a bar spacing of approximately 2/3 of the conduit dimensions. Because the control tower is recessed into the embankment, requiring an approach channel formed by retaining walls, the trash rack will be inset between the walls at a 45 degree angle.

(b) Tower and gates. - The 53.6-foot tall, 13-foot by 13.25-foot control tower will be constructed of reinforced concrete. The tower will be completely enclosed above the conduit and will be kept dry at

all times. Drainage for the control shaft chamber floor will be provided by a sump that will discharge to the service gate air vent pipe. The sump will be provided with a float switch that will activate an outside siren in the event of an abnormal water level condition (flooding) in the sump area. The tower will house a set of tandem emergency and service gates and their operating mechanisms to regulate releases into the conduit.

The control gates will be 3-foot by 3-foot wedge lock type slide gates. The upstream gate will act as the emergency gate and the downstream gate as the service gate. The gate assembly consists principally of the gate leaves, the upstream and downstream gate frames, frame extensions, bonnets, bonnet covers, and a locking system to insure a tight seal at low operating heads.

The gate controls will be located in a room at the top of the tower. The gates will be operated by means of electric motors through stems which will run down the inside of the tower shaft. The operating mechanisms will have manual override capabilities. The gates will be housed in covered slots in the floor of the shaft, above the conduit. A ladder will provide access from the control room to the floor of the control chamber shaft. The control shaft and control chamber will be ventilated by the air vent to the conduit provided for vacuum relief. In addition, a portable ventilator will be provided for use during inspections. A wall louver will be installed in the control chamber to provide an outside air source. A 75-foot long pedestrian bridge will provide access to the tower from the crest of the dam. The gate chamber will be serviced by an 8-ton (estimated) winch for removing the controller, gate leaves and other necessary items for maintenance and replacement.

(c) Conduit. - The 188.2-foot long reinforced concrete outlet works conduit will be 3 feet wide by 3 feet high. The conduit will be steel-lined from the emergency gate to 5 feet downstream of the service gate to minimize the possibility of cavitation damage when flows are regulated by small gate openings. A 6-inch diameter air vent will be provided in the roof of the conduit downstream of the service gate for vacuum relief. The conduit slope will be 0.02954.

(d) Energy Dissipator. - The outlet works conduit will discharge into an impact basin energy dissipator. The conduit invert elevation at the basin inlet will be 394.5. The basin was designed for a maximum discharge of 150 cfs at the maximum SPF pool elevation of 433.2. The conduit will have a horizontal slope for 3.0 feet upstream of the exit. The dimensions of the impact basin will be 12.0 feet wide by 17.0 feet long. The proposed exit channel will be 14.0 feet wide, with riprapped side slopes and bottom and will tie into the existing exit channel of the same size.

(2) Little Dry Creek Outlet Works. - Because the existing outlet works is located in a cut between two knolls, the most economical location for the new outlet works is the location of the existing outlet works, reducing the need for additional excavation. This will necessitate the removal of the entire existing facility and backfilling with lean mix concrete to the foundation grade for the new facility. The outlet works will be gated to limit the maximum flood release to 700 cfs, the existing

downstream channel capacity. Plates B4 and B5 show the plans and sections for the Little Dry Creek outlet works.

(a) Approach and Intake. - The approach channel for Little Dry Creek outlet works will be 18.3 feet long, extending from the intersection of the upstream slope of the embankment to the control tower inlet. The channel invert will be set at elevation 403.0. Elliptical side wall and roof curves will be provided at the conduit intake. The side wall and roof curves will have an x-dimension of 1.0 times and a y-dimension of 0.67 times the gate passage width of 3.0 feet and height of 6.5 feet, respectively. The inlet trash rack will be 15 feet wide by approximately 12 feet high with bar spacing based on 2/3 of the gate passage way dimensions. As for Big Dry Creek outlet works, the trash rack will be inset between the approach channel retaining walls at a 45 degree angle.

(b) Tower and Gates. - The 50.6 foot tall, 13.25-foot by 17-foot control tower will be constructed of reinforced concrete. As with the Big Dry Creek tower, the Little Dry Creek tower will be kept dry at all times. The tower will house two sets of tandem emergency and service gates placed side by side. Each set of gates will be capable of independent operation. Both sets of gates will be located in covered slots in the control chamber floor and will be operated from a control room located at the top of the tower. The gate assemblies will consist principally of the gate leaves, the upstream and downstream gate frames, bonnets, bonnet covers, and a locking system to insure a tight seal at low operating heads. Each gate will be a 6.5 feet by 3.0 feet wedge lock slide gate. The upstream gates will be the emergency gates and the downstream gates will be the service gates. As with Big Dry Creek, operation of the gates will utilize electric motors located in the control room and stems supported by wall brackets. The operating mechanisms will have manual override capabilities. A ladder will connect the control room to the floor of the control chamber shaft. The control shaft and control chamber will be ventilated by the air vent to the conduit provided for vacuum relief. In addition, a portable ventilator will be provided for use during inspections. A wall louver will be installed in the control chamber to provide an outside air source. A 57-foot long pedestrian bridge will provide access to the tower from the dam crest. The gate chambers will be serviced by an 8-ton (estimated) winch for removing the controller, gate leaves, and other items for maintenance purposes.

(c) Conduit. - The outlet works conduit will consist of a rectangular reinforced concrete conduit 5.0 feet wide by 6.5 feet high connected to a dual intake passageway at elevation 402.69 feet, Station 9+58.75. Each intake passage will be 3.0 feet wide by 6.5 feet high. A 5-foot thick center pier will separate the intake passageways. Steel lining will be provided from each emergency slide gate to 5 feet downstream of each service slide gate to protect against the possibility of cavatation damage. Eight (8)-inch diameter air vents will be provided in the roof of each conduit for vacuum relief downstream of the service gates. The air intakes will be positioned above the maximum pressure head expected in the conduit. A 24-foot section downstream of the lining will provide a transition from the dual gate section to the single 5.0-foot wide by 6.5 feet high conduit. The

conduit slope will be 0.0129. Each gate section has been sized to pass 80 percent of the maximum 700 cfs discharge.

(d) Energy Dissipator. - The conduit will exit at invert elevation 401.0 onto a parabolic drop leading to a hydraulic jump stilling basin. The stilling basin has been designed for the maximum anticipated discharge of 700 cfs at gross pool. The stilling basin will have an apron elevation of 387.0 feet, a width of 16.5 feet, and a length of 32.0. The parabolic drop will be 41.93 feet in length with a flare ratio of 6.97. A radius of 25 feet, will connect the side wall of the conduit to the parabolic drop flare. Two rows of baffle blocks will be provided. Baffle block height, width and spacing were set at 1.0 foot. The first row of baffles will be located 16.0 feet downstream from the start of the basin. The second row of baffles will be set approximately 6.0 feet downstream of the first row. The end sill will be 0.5 feet high.

(e) Exit Channel. - The exit channel will be 20.0 feet wide at the end of the stilling basin, converging on a 1 on 10 angle to the existing channel width. A preformed scour hole 5.0 feet below the stilling basin end sill will be provided. The exit channel will have an adverse bottom slope of 0.1 from the scour hole invert to the existing exit channel invert. The riprap removed from the existing channel during demolition of the existing stilling basin will be replaced to protect the bottom and side slopes of the reconstructed portion of the exit channel.

The existing exit channels of both Big Dry Creek and Little Dry Creek outlets have not experienced any significant erosion problems over their 37 year life.

d. Dry Creek Crossing of the Friant-Kern Canal. - The Dry Creek crossing of the Friant-Kern Canal (Canal Station 820+00) and the adjacent east side canal embankments will be modified so that co-mingled Standard Project Flood (SPF) flows from Dry and Dog creeks can safely pass over the canal and into Big Dry Creek Reservoir. A plan of the crossing area and proposed modifications are shown on Plate B45.

(1) Canal Crossing. - The top of the upstream and downstream cross drain head walls currently are at elevations 466.27 and 465.88, respectively. The two 65-foot long head walls will be raised by approximately 4.0 feet to elevation 470.0. The raised head walls include 3 feet of freeboard. In addition, an inverted "T" shaped wing wall will be added, extending each of the head walls about 40 feet on the upstream side of the Dry Creek crossing. The wing walls will serve to retain the adjacent raised embankment. A structural analysis of the siphon indicated that both with and without the proposed modifications the structure was marginally able to withstand the loading from a SPF. A more detailed evaluation of this structure will be performed during Feature Design Memorandum studies.

(2) Friant-Kern Canal Embankment. - The Friant-Kern Canal embankment on the upstream side of the crossing will be raised from the top of the existing embankment (elevation 466.0 to 467.0) to 470.0. The raised embankment will extend from the crossing, northwest about 750 feet to where

it will tie into an existing knoll. The embankment will have a top width of 20 feet, 1V on 2.25H side slopes, and 3 feet of freeboard. The embankment will be raised in a manner which will allow the road on the existing embankment to be preserved for inspection and maintenance of the Friant-Kern Canal.

(3) Dry Creek Diversion Embankment. - The Dry Creek diversion embankment is part of the existing Big Dry Creek project. The portion of the embankment east of the Friant-Kern Canal will be raised in a manner similar to the Friant-Kern Canal embankment. The raised portion will have a top width of 20 feet and side slopes of 1V on 2.25H. The raised portion consists of two sections. The first section, with crest elevation 470, extends southeasterly for approximately 400 feet from the downstream siphon headwall. The second section, with crest elevation 471.0, extends northeasterly for approximately 1,300 feet where it ties into the existing ground. Plans and sections are shown on Plate B45.

(4) New-Embankment. - In addition to raising the existing Friant-Kern Canal embankment and Dry Creek embankment, two new embankments will be constructed in the crossing area to contain SPF flows, insuring that they will pass over the Friant-Kern Canal. They will be located northeast of the crossing and tie into the natural ground at elevation 471.0. The two embankments will have crest elevations of 471.0, a maximum height of 5 feet, 3 feet of freeboard, a crest width of 10 feet, and 1V on 2.25H side slopes as shown on Plate B45. They will be 100 and 300 feet long.

e. Permanent Operating Equipment. - The Little Dry Creek outlet works control tower will be provided with equipment to record precipitation, pool level, gate position, and outlet channel stage data and provide for retrieval of this data by phone from remote locations (FMFCD's office). Also, this equipment will permit the service gates to be operated from a remote location. A power line to be relocated from the pool area to along the downstream side of the Big Dry Creek Dam embankment, within the guide taking line for fee acquisition, will be sufficiently close to the control tower to provide power. A phone line will have to be provided. A second phone will be installed in the tower for use by an operator. Provisions will be made for retrofitting radio telemetering equipment at the option of the Local Sponsor.

(1) Precipitation Gage. - A precipitation gage near Big Dry Creek Dam is needed to collect precipitation data required for calculating the cumulative precipitation parameter (Chapter XIII - System Operation). The gage will be located just downstream of the Little Dry Creek outlet works stilling basin, along with other equipment, and be hard wired to the control tower for data collection and transmission.

(2) Stage Gages. - Three stage gages are needed for Big Dry Creek Dam. Two will be installed in the Little Dry Creek outlet channel and one in the reservoir pool. The stage gages will consist of a float well with a recorder. One gage is needed at the outlet channel wasteway, about 1.44 miles downstream of the outlet works, so that the project can be operated without flows at the wasteway exceeding the channel capacity. This gage will

have a remotely interrogatable recorder to permit data retrieval by phone. A second gage will be located just downstream of the outlet works stilling basin, with the precipitation gage, to check the gate releases, and will be hard wired to the control tower for data recording and transmission. The third float well will be installed at the tower to measure pool levels. This data will be recorded in and transmitted from the tower.

(3) Staff Gages. - Three staff gages will be provided with the three float wells for gage calibration and back up. A fourth staff gage will be located just downstream from the Big Dry Creek outlet works for verification of the outlet works rating curve and collection of flow data.

(4) Gate Operation. - Gate control equipment at both Little Dry and Big Dry outlet works will be provided so that the service gates can be operated from both the control tower and FMFCD's operations office. Remote control will be via phone lines to the control towers.

(5) Emergency Gates. - The emergency gate controls at both outlet works will be provided with a micro-switch alarm to indicate when the emergency gates are closed. This will help to insure that the gates are kept in the raised position under normal operating conditions. The capability of retro-fitting the gates with remote controllers will be provided as part of the design.

f. Electrical Facilities and Equipment. - Both Little Dry and Big Dry Creek control towers will require similar electrical facilities. In each tower, lighting will be provided in the gate operating chambers by vapor tight lighting units of an average intensity of 30 foot-candles. Portable rechargeable emergency electrical lights will be located in the gate operating chambers and the control shaft. Lightning protection for the control towers will be provided. An intercommunication and call-bell system will be provided for communication and signaling between the control room and gate chamber in each control tower by using chest-type portable sound-powered telephone sets. Hand and chest-type portable sound-powered telephone sets with cable-reel and enclosure will be installed in each gate chamber. Wall-mounted handsets will be installed in the control rooms and shafts.

At Big Dry Creek outlet works, the electrical facilities will include three 5-KVA transformers to be connected delta-delta, 12 KV, 120/208V, 4-wire, 3-Phase. At Little Dry Creek outlet works, the electrical facilities will include three 10-KVA transformers that will be connected delta-delta, 12 KV, 120/208 V, 4-wire, 3-Phase. The electric power extensions and transformer banks and telephone service between the FMFCD's operating office and the control towers will be supplied by the servicing utility company. All enclosures for electrical equipment located in the control tower will be provided with National Electrical Manufacturers Association (NEMA) Type IV enclosures. Electrical conduits provided will include one 2-inch conduit for telephone service from the control towers to the nearest power pole, two 1-1/4-inch conduits for future installation of radio communication equipment from the control towers to stub-outs on the roof, and one 1-1/4-inch conduit, terminated in the control room for exterior security type floodlighting.

Description of the Selected Plan

21. Fancher Creek Dam. - The proposed Fancher Creek Dam will be located on Fancher Creek, adjacent to and just east of the Friant-Kern Canal. It will be constructed solely for flood control purposes. The Dam will intercept and temporarily store flows from Fancher Creek, Hog Creek, and several unnamed tributaries to Redbank Creek. Fancher Creek Dam will have a gross pool capacity of 10,304 acre-feet and will operate in conjunction with Redbank Creek Detention Basin to provide protection from a 200-year or more frequent flood. The ungated outlet works and spillway will be combined into one structure so that the existing cross drainage structure at Friant-Kern Canal Station 1126+60 can be used to discharge flows to Fancher Creek west of the canal. The plan for the dam and reservoir and design details are shown on Plates F1 and F2.

a. Embankment. -

(1) Alignment. - The proposed dam alignment will parallel the Friant-Kern Canal for approximately 6,800 feet (Station 12+00 to 80+00) at a minimum distance of 195 feet from the downstream toe to the centerline of the canal. From Station 80+00 north, the dam alignment parallels Madsen Avenue at a minimum distance of 550 feet from the downstream toe to the centerline of the road, Plate F1.

(2) Typical Sections. - The embankment section was designed in accordance with criteria contained in EM 1110-2-2300 (Earth and Rock-Fill Dams - General Design and Construction Considerations) and EM 1110-2-1902 (Stability of Earth and Rock-Fill Dams). General features of the embankment section include a 25-foot crest width, 3 feet of freeboard, a central impervious core, a cutoff trench, and a downstream horizontal drainage blanket with toe drain. The embankment will be about 16,900 feet long. The upstream slope will be broken with a 1V on 2H slope descending from the crest to elevation 490.0 and then flattening to 1V on 3H. Downstream, the slope is 1V on 2H. The slopes will be turfed. The upstream slope will be readily accessible by maintenance equipment.

(3) Seepage Control. - The proposed seepage control features will minimize flows and prevent piping. The natural impervious surface deposits which mantle the foundation to about 500 feet upstream of the dam will be preserved in order to provide seepage control by lengthening potential foundation seepage paths. An inspection trench will intercept pervious water bearing layers near the surface. An impervious core will limit seepage through the embankment. Minor seepage through the core and upper foundation will be collected in a 3.75-foot thick horizontal blanket and toe drain. The horizontal blanket will be constructed of gravel and will be protected by 9 inches of filter material on the bottom and 12 inches on top. Seepage in the toe drain will be collected in a slotted 18-inch diameter CMP pipe. Toe drain pervious fill will be encapsulated with filter fabric. The toe drain pipe will convey seepage toward the foundation low point, where it will be discharged under the Friant-Kern Canal at canal Station 1072+52. An outfall pipe will be driven under the Friant-Kern Canal for this purpose, if the existing siphon invert elevation is not low enough to correspond with the toe drain discharge point.

(4) Slope Protection. - Based upon a careful analysis described in Chapter VI - Geology and Construction Materials, considering past operational performance of similar facilities in the project area, and duration of exposure, the following slope protection provisions are proposed for Fancher Creek Dam.

A ten-foot horizontal width of sandy clay (CL), seeded with turf, will blanket the upstream slope of the embankment. This zone will extend from the toe to the dam crest. Beaching of this material is not anticipated. However, if minor erosional damage were to occur, the relatively flat upstream slopes will afford easy maintenance access during dry summer months. Downstream slope protection will be provided by turf. Specifications will require the contractor to establish turf protection before the advent of winter rains.

(5) Excavation and Fill Quantities. - The sources and quantities of excavation and fill material are shown on Plate F27, along with shrinkage and bulking factors. Embankment fill quantities are summarized in Table 9.

b. Spillway. - The 60-foot wide spillway crest will be set at elevation 480.5, the maximum pool elevation experienced during routing of the 200-year design flood event through the reservoir. Because of the suitable site topography and the desire to utilize the existing 30-foot wide Fancher Creek overchute of the Friant-Kern Canal, the spillway has been designed as a high ogee section passing through the dam embankment. The peak spillway design flood (SDF) inflow is 20,600 cfs and the corresponding maximum combined spillway and ungated outlet works discharge is 7,100 cfs. The maximum SDF pool elevation will be 490.3. A structural analysis of the overchute showed that with the proposed midifications the structure was marginally able to withstand the loading from the peak SDF. A more detailed evaluation of this structure will be performed during Feature Design Memorandum studies. The spillway and outlet works design is shown on Plate F2.

The ogee crest was designed for a head of 9.8 feet and will terminate on a slope of 1V on 0.75H. A toe curve with a 20-foot radius will connect the ogee crest to the spillway chute at invert elevation 457.8. The 60-foot wide spillway chute will converge to the 30-foot wide Friant-Kern Canal overchute over a distance of 160 feet. The new hydraulic jump stilling basin to be constructed on the west side of the Friant-Kern Canal will be 68 feet long and 40 feet wide with an apron elevation of 435.7. Two rows of baffle blocks will be provided. Baffle block height, width, and spacing are set at 3.5 feet. The first row of baffles will be set 34 feet downstream from the start of the stilling basin. The second row of baffles will be placed 12.0 feet downstream from the first row. The stilling basin walls will provide 3.0 feet of freeboard. The end sill will be 1.0 foot high. The adverse channel slope downstream of the endsill will be initiated 1.0 foot below the end sill elevation. The exit channel will be riprapped and provided with a preformed scour hole.

c. Outlet Works. - The outlet works will be placed through the ogee spillway with an invert elevation 457.8. The outlet works will be a square concrete conduit, 3 feet wide by 3 feet high fitted with a steel flow

Table 9

Embankment Fill Quantities
Fancher Creek Dam

Embankment Fill Zone	Material Type	Material Source	Required Fill (C.Y.)
Toe Drain	Drainage Fill	Commercial	16,000
Horizontal Drain	Drainage Fill	Commercial	59,000
Service Road	Stabilized Aggregate	Commercial	3,000
Upstream Impervious Blanket	Sandy Clay	Foundation Stripping and Dike Removal	23,000
Upstream Toe Leveling	Sandy Clay	Foundation Stripping, Spillway and Outlet Works Excavation	53,800
Slope Protection	Sandy Clay	Foundation Stripping and Dike Removal	178,000
Random Fill	Random Fill	Toe Drain Excavation and Borrow Area	15,000 1,326,000
Impervious Core	Impervious Fill	Inspection Trench Borrow Area	107,000 375,000
Filter	Filter Material	Borrow Area (Big Dry Dam)	67,000

restrictor to limit the maximum discharge to 100 cfs at gross pool. Although flow is open channel downstream of the restrictor, a 6-inch diameter air vent will be provided to ensure a positive air supply to prevent cavatation at the flow restrictor. An eyebrow will be provided at the conduit exit to prevent damage caused by spillway flows. Elliptical side wall and roof curves will be provided at the intake with x and y dimensions of 1.0 times and 0.67 times the conduit dimension of 3.0 feet, respectively. The conduit entrance will be protected by a trashrack 6.5 feet wide and 9.0 feet high with bar spacing of 2 feet wide by 0.75 feet high based on 2/3 of the restrictor opening.

d. Permanent Operating Equipment. -

(1) Precipitation Gage. - A precipitation gage in the Fancher Creek Dam drainage basin is needed to collect data required for calculating the

cumulative precipitation parameter (Chapter XIII - System Operation). The system will include a remotely interrogatable recorder for data retrieval by phone. It will be located near a relocated phone line.

(2) Stage Gage. - A stage gage consisting of float well and recorder is needed for the Fancher Dam pool to obtain a record of reservoir storage. This will not be remotely interrogatable but will be provided with the capability to have a data transmission system installed at the option of the local interests. Thus, power will not be required at this site.

(3) Staff Gages. - A staff gage will be provided along with the float well for back up and gage calibration. A second staff gage will be provided just downstream of the stilling basin to check the outlet works rating curve and collect flow data.

22. Pup Creek Detention Basin. - Pup Creek Detention Basin will be located on Pup Creek, a tributary to Dry Creek, just northeast of the intersection of Temperance and Bullard avenues. The basin will be a partially excavated - partially embankment contained facility. It will have a capacity of 495 acre-feet and has been designed to control the 200-year flood event with a maximum release of 25 cfs. Flows will be controlled by an ungated outlet works. A spillway will not be provided. The site plan and design details are shown on Plate P1.

a. Typical Sections. -

(1) Excavation. - The detention basin will be excavated to elevation 366.0 with cut slopes of 1V on 8H. The cut slopes are provided at the request of the local project sponsor to facilitate maintenance and multiple use of the basin. Pup Creek enters the basin from the east, just downstream from where it flows under Locan Avenue. The inlet area will have cut slopes of 1V on 4H.

(2) Embankment. - To provide storage up to the design water surface elevation of 376.8, a 710-foot long embankment will be constructed at the southwest corner of the basin. This embankment section will have a maximum height above final ground of 3.0 feet, no freeboard allowance, 1V on 8H inside slopes, 1V on 2H outside slopes, and a crest width of 10 feet. A small depression in the natural ground adjacent to the southwest corner of the basin will be filled with compacted material to elevation 373.8, to emulate natural ground, so that the embankment height will not exceed 3.0 feet.

(3) Erosion Protection. - Since a spillway will not be provided for this facility, the embankment section will be capped with a soil cement layer to protect the crest, outside slopes, and downstream toe area from erosion damage due to overtopping flows resulting from a flood event which exceeds the 200-year design event. The basin and invert cut slopes will be protected with native grasses which will provide adequate protection against erosion on the mild slopes.

Flood flows overtopping North Locan Avenue will enter the basin over a 425-foot long section of the cut slope. This section will also be protected from erosion by soil cement. The slope will be excavated at 1V on 4H to reduce the cost of the protection. The remaining basin will be excavated on a 1V on 8H slope. Details of the erosion protection are given in Chapter VI - Geology and Construction Materials.

(4) Excavation and Fill Quantities. - The excavation volume required for the basin is approximately 975,200 cy. The embankment requires 1,980 cy of compacted fill with 1,555 cy of soil cement cover. The inlet area will be covered with 1,120 cy of soil cement. Excavation for the outlet works and the 640-foot long open portion of the exit channel totals 8,400 cy. Required excavation for the 2,320-foot piped portion of the exit channel totals 6,500 cy.

b. Outlet Works. -

(1) Approach. - The approach to the outlet works will consist of a horizontal 44-foot long "U"-shaped reinforced concrete structure with the top of the walls sloped to match the excavated basin slopes and an invert elevation of 366.0. A trashrack will be provided at the intake to protect the orifice opening from debris. The trashrack will be 4.0 feet wide and extend to elevation 370.0 between the vertical retaining walls which are required because the outlet works will be set back into the cut slope. The trashrack will be placed on a 2V on 3H slope with horizontal bar spacing along the slope set at 1.0 foot; one vertical bar will be placed in the center. A staff gage will be provided at the outlet works to measure pool stage.

(2) Conduit. - The 66-foot long outlet works conduit will consist of a 3.0-foot diameter precast concrete pipe encased in a 5.5 by 5.5-foot cast-in-place reinforced concrete section. The size was chosen as the minimum acceptable for inspection purposes. Consequently, a steel flow restrictor plate will be required at the intake to limit the maximum discharge to the required 25 cfs at maximum pool. The flow restrictor will be a flat, square-edged plate essentially acting as a slide gate in a circular conduit. Slotted bolt holes will be provided in order to field adjust the position of the flow restrictor. The lower edge of the restrictor plate will be placed 1.32 feet above the conduit invert elevation of 366.0 feet. The conduit will have a slope of 0.0003.

(3) Energy Dissipator. - A rock-lined scour hole will be provided at the conduit exit for energy dissipation. Because of the high exit velocity, the approach slope from the conduit exit to the scour hole floor will be set at 1V on 10H to provide additional length for the flow to spread. At the conduit exit, the flow depth will be 0.8 feet and the velocity 16.5 fps. The approach slope, the scour hole floor, and the side slopes to the end of the scour hole floor will be grouted to prevent erosion of the rock layer. The upper 1/3 of the surface rock will be left exposed to provide frictional resistance. The scour hole will be 1.5 feet deep, 6.0 feet wide, and 9.0 feet long. Scour hole side slopes will be 1V on 3H from the bottom up to 1.5 feet, and 1V on 2H to the top of cut. A 1V on 3H

adverse slope will connect the scour hole floor with the downstream exit channel. Ungrouted rock will be provided on the adverse slope and for 10 feet downstream of the scour hole. A rock layer thickness of 15 inches will be required. A staff gage will be provided just downstream of the energy dissipator to allow for checking the outlet works rating curve and measuring outflow.

(4) Exit Channel. - The exit channel will consist of a 640-foot long section of open channel followed by a 2,320-foot long section of pipe following the alignment of Pup Creek. The open portion of the exit channel will have a 10-foot bottom width with 1V on 2H side slopes, and an invert slope of 0.0003. The open channel will extend from the outlet works to North Temperance Avenue. At North Temperance Avenue, the existing culvert will be replaced by one 48-inch diameter reinforced concrete pipe. From North Temperance Avenue, flows will be carried in a 48-inch diameter buried pipe which will connect to the storm drain system about 2,320 feet downstream. The exit channel pipe was sized for a capacity of 40 cfs to be compatible with the local piped storm drain system. The 40 cfs consists of a maximum basin discharge of 25 cfs plus 15 cfs downstream of local inflow from a 10-year storm.

23. Alluvial Drain Detention Basin. - Alluvial Drain Detention Basin will be located on Alluvial Drain, a tributary to Dry Creek, just east of the Enterprise Canal. It will require 57 acres of land. The basin will be a completely incised, excavated below ground, and require no spillway. Flows will enter the basin from the east just downstream from where the Drain passes under Temperance Avenue and from an unnamed tributary to the north. The basin will have a storage capacity of 385 acre-feet and has been designed to control the 200-year flood event with a maximum outflow of 25 cfs. Outflows will be released to the existing Alluvial Drain channel. A general site plan and design details for Alluvial Drain Detention Basin are shown on Plate A1.

a. Typical Sections. -

(1) Excavation. - Alluvial Drain Detention Basin will be totally excavated below grade. It will be approximately 10-feet deep with a basin invert elevation of 377.9. Side slopes will be cut to 1V on 8H, as per the request of the local sponsor to facilitate maintenance and multiple use of the basin. The inlet slopes will be cut to 1V on 4H. The basin construction will require excavation of 685,900 cy of unclassified material.

(2) Slope Protection. - The earth lined exit channel and detention basin slopes will be protected with native grass. Outlet works transition slopes will be protected with riprap. Flood flows from the East will enter the basin over a 335-foot long section of the cut slope. This section will be protected from erosion by a soil cement cap. The 1V on 4H inlet slope reduces the cost of slope protection. Flood inflows from the north also will enter the basin over a soil cement protected cut of 1V on 4H slope.

b. Outlet Works. -

(1) Approach. - The intake is designed as a 26-foot long, "U"-shaped, horizontal, reinforced concrete structure with the top of the walls sloped to 1V on 4H. A trashrack will be provided at the intake to protect the orifice opening from debris. The trashrack will be 4.0 feet wide and extend from elevation 377.9 to elevation 381.9 on a slope of 1V on 1.5H between the vertical retaining walls. The horizontal bar spacing will be 1.0 foot; one vertical bar will be placed in the center. A staff gage will be provided at the outlet works to measure pool stage.

(2) Conduit. - The 112-foot long conduit will consist of a 3.0-foot diameter precast concrete pipe encased in a 5.5 by 5.5-foot cast-in-place reinforced concrete section. The conduit will pass basin outflows under the Enterprise Canal. The conduit size was chosen as the minimum acceptable for inspection purposes. Consequently, a steel flow restrictor plate will be required at the intake to limit the maximum discharge to the required 25 cfs at maximum pool. The flow restrictor will be a flat, square-edged plate essentially acting as a slide gate in a circular conduit. Slotted bolt holes will be provided in order to field adjust the position of the flow restrictor. The lower edge of the restrictor plate will be placed 1.4 feet above the conduit invert elevation of 377.9 feet. The conduit slope will be 0.0003.

(3) Energy Dissipator. - An existing swale downstream of the conduit exit will be shaped to provide a rock lined scour hole for outflow energy dissipation. At the conduit exit the flow depth will be 1.05 feet and the velocity will be 11.2 fps. Because of the high exit velocity, the approach slope from the conduit exit to the scour hole floor will be set at 1V on 10H to provide additional length for the flow to spread. The approach slope, the scour hole floor and the side slopes to the end of the scour hole floor will be grouted rock to prevent erosion of the rock material. The upper 1/3 of the surface rock will be left exposed to provide frictional resistance. The scour hole will be 1.5 feet deep, 6.0 feet wide, and 9.0 feet long. Scour hole side slopes will be 1V on 3H to 1.5 feet, the height of the scour hole proper, and 1V on 2H to the existing ground elevation. A 1V on 3H adverse slope will connect the scour hole floor with the downstream exit channel. Ungrouted rock will be provided on the adverse slope and for 10 feet downstream. A rock layer thickness of 12 inches would be required. However, because it will be more economical to have the same gradation for both Pup Creek and Alluvial Drain basins, a 15-inch rock layer was selected. A staff gage will be provided just downstream from the energy dissipator to check the outlet works rating curve and measure outflow.

(4) Exit Channel. - The exit channel will be about 2,000 feet long, extending from Armstrong Avenue to meet the natural channel bed elevation. It will have a 5-foot bottom width with side slopes of 1V on 2H and a bottom slope of 0.0003. The exit channel capacity will be 25 cfs. At Armstrong Avenue, 600 feet downstream of the outlet works, the existing culvert will be replaced by a 50-inch wide by 31-inch high precast concrete arch culvert. The culvert was oversized so as not to significantly increase the tailwater at the outlet works. The tailwater is expected to be 0.1 feet greater than the normal depth of 1.8 feet.

24. Redbank Creek Detention Basin. - Redbank Creek Detention Basin will be located just upstream from the confluence of Mill Ditch and Redbank Creek. The 940 acre-foot basin will be partially excavated and partially embankment contained. The basin invert will be set at elevation 342.2 and the embankment crest at the design water surface elevation of 349.3. A spillway will not be provided. Flows will enter the basin from Redbank Creek, to the north. Outflow will be discharged to Mill Ditch via an exit channel formed from the existing Redbank Creek channel. Basin outflow will be regulated by two automatically controlled gates. The gates will operate to limit releases from Redbank Detention Basin to a maximum of 200 cfs. The basin is designed to control a 200-year flood event originating in the Redbank Creek and Dog Creek drainage basin. Mill Ditch, currently flowing through the basin site, will be relocated to just outside the southern boundary of the basin. A general site plan and design details are shown on Plates R1 and R2.

a. Typical Sections. -

(1) Excavation. - The basin will be excavated to elevation 342.2 with cut slopes of 1V on 8H. The rerouted Mill Ditch channel geometry will incorporate 1V on 3H side slopes and a 12-foot bottom width. The channel invert slope will be 0.0013 and depths will range from 9.5 feet to 15 feet, depending on the elevation of the natural ground.

(2) Embankment. - To provide storage up to the design water surface elevation of 349.3 retention embankments will be provided at several locations along the southern and western portions of the basin perimeter. These embankments will have a maximum height of 3 feet above natural ground, no freeboard allowance, 1V on 8H inside slopes, 1V on 2H outside slopes, and a crest width of 10 feet. Maintenance access will be provided along the 10-foot wide crest. A similar embankment will be placed along the northside of Redbank Creek. The section of this embankment will be the same except that inside slopes will be 1V on 2H, and the maximum embankment height is 2.9 feet.

(3) Erosion Protection. - Erosion protection at Redbank Creek Detention Basin involves three distinct zones, the basin invert and cut slopes, Mill Ditch, and the retention embankment slopes. The basin invert and cut slopes will be protected with native grasses which will provide adequate protection against erosion on the mild slopes. The bends of rerouted Mill Ditch will experience flow velocities of up to 4 fps for sustained periods during the irrigation season. Consequently, gabions will be installed along the outside of each bend to provide flexible erosion protection in these areas. Since a spillway will not be provided for the facility, the embankments will be capped with a soil cement layer to protect the crest, outside slopes, and downstream toe area from erosion damage due to overtopping flows resulting from a flood event which exceeds the 200-year design event. Details of the erosion protection are given in Chapter VI - Geology and Construction Materials.

b. Control Structure. - Outflow from Redbank Creek Detention Basin will be controlled by a gated structure across Redbank Creek, located in the northwest corner of the basin, about 2,800 feet upstream from Temperance

Avenue. The control structure will consist of a gate support structure, flanked by two 45-foot long wing walls. The gate support structure will be formed as a three-sided concrete box 25.3 feet high, 36 feet wide and 29.75 deep (from upstream to downstream end), open on the top and downstream sides. A plan and sections are shown on Plate R2. The upstream side of the structure will contain two 4.1-foot square orifices. Flow through these orifices will be regulated by two bouyancy-activated gates that are automatically controlled by downstream water surface elevations. The gates operate without power or manual manipulation. The gates will be set during their installation to maintain a downstream water surface elevation of 338.5±0.1 which corresponds to a flow of 200 cfs in the exit channel, just downstream from the gates. The gates can be manually closed for emergency purposes. Each wing wall will be made up of two 15 foot long L-wall sections, adjacent to the gate support structure, and three 15-foot long U-wall sections. The gate support structure and wing walls will be founded on at least 2 feet of recompacted backfill and imbedded in 3.5 feet of compacted backfill to insure sufficient bearing capacity. The space between the upstream and downstream faces of the wing walls will be backfilled to elevation 349.3 as shown on Plate R2.

c. Permanent Operating Equipment. -

(1) Stage Gages. - Two stage gages with remotely interrogatable recorders are needed for the detention basin. One gage and recorder is needed in Mill Ditch at the Temperance Avenue control point to monitor flows during flood control operations. A second gage and recorder is needed in the basin to monitor basin storage. The gages will consist of a float well and recorder which will be remotely interrogatable by phone. Provisions will be made for retrofitting the gages with radio telemetering equipment at the option of the Local Sponsor.

(2) Staff Gages. - Three staff gages are needed at Redbank Creek Detention Basin. A staff gage will be provided with each of the two float wells as back up and for gage calibration. A third staff gage will be provided in the exit channel just downstream from the control structure for checking the gate rating curve and measuring outflows.

25. Introduction. - This chapter contains a hydrologic description of the project area, and information on the development of the project design floods, development and operation of a model of the project facilities and existing waterways in the area, reservoir sizing, sedimentation, and hydraulic design of discharge facilities. The hydrologic information presented here is supported by Appendix A - Hydrology.

26. Hydrologic Description of the Project Area. - The project area is located on the western slopes of the Sierra Nevada foothills in eastern Fresno County, between the San Joaquin and Kings Rivers, Plate G1.

a. Streams and Canals. - The principal streams in the project area are Dry Creek, Dog Creek, Redbank Creek, and Fancher Creek. Other local streams of interest are Alluvial Drain, Hog Creek, Pup Creek, and Mud Creek. Flood plains extend from the foothills down to Fresno Slough and on to the San Joaquin River, west of the City of Fresno. These creeks flow in natural channels through the foothills and emerge onto the valley floor east of Fresno. There, the stream channels have been extensively modified and, in effect, now are dual purpose; the channels are used for conveying both irrigation water supplies and storm runoff. These dual purpose channels flow across agricultural land and through the Fresno-Clovis metropolitan area. The major dual purpose channels are the Fresno Canal, Mill Ditch, Dry Creek Canal, and the Herndon Canal. Other major canals in the area are the Friant-Kern Canal, Enterprise Canal, and Gould Canal. These canals cross the above mentioned creeks, changing the natural drainage patterns in the project area. The result is that flood flows intercepted by the Enterprise and Gould canals are carried out of their natural basins and into other basins and any runoff entering the Friant-Kern Canal is transported out of the project area. Plate G2 shows the project area streams and canals.

b. Topography. - The topography of the project area ranges from the moderate to steep hills and ridges of the foothills to the nearly flat alluvial plains of the eastside San Joaquin Valley, Plate H6. The highest elevation, 4,700, is in the Dry Creek headwaters, while the lowest elevation, about 350.0, occurs on Mill Ditch southeast of Clovis. The alluvial fan area south and west of the foothills consists of material deposited by the streams draining the foothills between the San Joaquin and Kings Rivers. The alluvial terrain is gently rolling on the terraces bordering the foothills and nearly level just east of Clovis.

c. Vegetative Cover. - The areas directly above the Friant-Kern Canal are predominantly well managed grasslands used mostly for grazing. Grass cover shares the higher elevations with scattered brush and stands of Blue Oak. In the highest part of the Dry Creek watershed, the woody cover of oak trees and brush is more extensive. The land between the Friant-Kern Canal and the Fresno-Clovis metropolitan area is flat, valley, agricultural land consisting mainly of orchards, vineyards, pastures, and field crops.

d. Climate. - The climate of the area is semi-arid, with hot, dry summers and cool, moist winters. Fog can occur frequently in December and January, when a high pressure system traps marine air in the Valley. The

foggy periods sometimes last longer than two weeks. The fog layer can be several hundred feet thick, but above it the mountain skies are clear and temperatures mild.

In the Valley, winds generally come from either direction of the northwest-southeast axis of the San Joaquin Valley, with northwest winds prevailing for most of the year. In the foothills, the air flows are usually upgrade in the afternoon and downgrade at night. The strongest winds occur in association with winter storms.

(1) Temperature. - During the summer, the Coast Range blocks the flow of cooling marine breezes; the normal daily maximum temperature rises to near 100° Fahrenheit (F) during the latter part of July. Except for infrequent cold spells, winter daytime temperatures are substantially above freezing. Heavy frosts occur almost every year between November and March. Temperature extremes observed in the area have ranged from 17°F to 116°F. Average temperatures drop about 3°F for every 1,000 feet of elevation above the valley floor. Mean monthly temperatures for four representative stations are shown in Table H-2 of the Hydrology Appendix.

(2) Precipitation. - Average annual precipitation over the project area varies from 10.5 inches east of Fresno to above 30 inches in the headwaters of Dry Creek. Most of this precipitation occurs between November and April. Thundershowers may move into the area during the summer. Winter precipitation usually falls as rain, although snowfall may occur down to 2,000 feet and occasionally lower. The climatological stations used in this study are listed in Table H-3, Appendix A. Plate H7 presents station locations and normal annual precipitation isohyetal lines. Mean monthly and annual precipitation amounts for four representative stations are shown in Table 10.

e. Runoff. - The only streamflow data available within the project area are from stations at Dry Creek near Academy and Dry Creek at Big Dry Creek Reservoir. Both stations are maintained by the Fresno Irrigation District. These and stations located just outside the study area, along with the maximum peak flows and major floods of record are listed in Table 11. Almost 90 percent of the runoff occurs during a five month period between December 1 and May 1 with little or no runoff occuring during the remaining seven months of the year. The locations of the stations on Dry Creek and Little Dry Creek are shown on Plate H1 and the estimated runoff volumes at the project sites are shown on Table H-12 and H-13 of the Hydrology Appendix.

f. Interior Drainage. - This project does not create any interior drainage problems. The project features consist of single purpose, flood control, upstream dams and detention basins. They are designed to temporarily store flood flows and do not interfere with local runoff. The project features will improve any interior drainage problems that might occur in the future by permitting faster evacuation of downstream local runoff without exceeding the capacity of the flood flow channels.

Table 10

Mean Monthly Precipitation

Month	Auberry 1NW[1/] (El. 2,140) (Inches)	Fresno WSO AP[1/] (El. 328) (Inches)	Friant[1/] Govt. Camp (El. 410) (Inches)	Pine[2/] Flat Dam (El. 615) (Inches)
January	4.60	2.05	2.51	3.77
February	4.01	1.85	2.29	2.91
March	3.57	1.61	2.04	2.78
April	2.60	1.15	1.50	1.91
May	0.82	0.31	0.47	0.58
June	0.16	0.08	0.12	0.15
July	0.04	0.01	0.12	0.03
August	0.04	0.02	0.02	0.02
September	0.44	0.16	0.27	0.25
October	0.91	0.43	0.59	0.67
November	2.61	1.24	1.67	2.00
December	4.04	1.61	2.23	3.04
Total Annual	23.84	10.52	13.83	18.11

1/ Average precipitation for 1951 - 1980.
2/ Average precipitation for 1953 - 1982.

Table 11

Recorded Maximum Peak Stream Flows

Station	Drainage Area (Sq. mi.)	Period of Record	Max Flood of Record (Date)	Peak Flow (cfs)
Dry Creek at Academy	44.0	Jan 41 to date	25 Jan 69	4,400
Little Dry Creek near Friant	57.9	Oct 41 to Sep 56	24 Dec 55	1,760 (est.)
Little Dry Creek at Mouth, near Friant	77.7	Oct 56 to date	22 Mar 58	4,700
Cottonwood Creek near Friant	35.6	Oct 41 to date	24 Feb 69	3,300
Big Dry Creek Reservoir	81.7	Oct 49 to date	25 Jan 69	5,700

g. Storm Characteristics. - Flood producing storms that cover the project area stream basins occur as rain during October through April. The majority of these storms occur from the latter part of December to the first part of April. There are two distinct types of storms: general storms that

produce widespread heavy precipitation, and local storms that produce extremely heavy short-term precipitation over small areas.

(1) General Storms. - The wide spread rains experienced during general storms result from the combination of orographic lift and convergence. These storms usually last from one to four days. During these frontal waves, there usually are several periods of high rainfall lasting several hours. The basin-wide precipitation pattern may vary considerably during a particular storm, and from one storm to another.

(2) Local Storms. - Local or cloudburst storms usually last from one to six hours and vary greatly in extent from a few square miles to less than one hundred square miles. Two basic kinds of cloudburst storms are characteristic of this meteorological region. The first results from convection activity during summer months. These storms fall on dry ground and have not caused significant flooding. The second kind of cloudburst storm occurs during the winter rainy season in association with general storms. They result from convection cells triggered by local convergence. Most of these local storms are relatively small and not easily distinguished from small general storms. If these convection cells are imbedded in a large convection general storm, severe flooding will occur.

h. Flood Characteristics. - Floods from foothill streams in the Fresno area result from large general rainstorms that occur during the late Fall and Winter or from cloudburst storms occurring during late Spring or early Fall. General rainfloods last several days and are characterized by high peak discharges and relatively small volumes. Cloudburst floods are characterized by extremely high peak-to-volume ratios. They are confined to relatively small areas and consequently have small volumes. Information on historic floods in the project area is presented in the Hydrology Appendix.

27. Project Design Flood Development. - A Standard Project Flood (SPF) and Probable Maximum Flood (PMF) were developed for designing Big Dry Creek Dam and Reservoir. A 200-year and PMF were developed for designing Fancher Creek Dam and Reservoir and 200-year floods were used to design the detention basins. The detention basins were not provided with spillways. Thus, PMF's were not developed for these facilities.

a. Flood Reconstitutions. - During the Feasibility Study a detailed analysis was made of the precipitation and runoff data from the floods of December 1955, March 1958, January 1969, and February 1969, on Dry Creek, Little Dry Creek, and Cottonwood Creek basins. The results of this analysis are discussed in "Redbank and Fancher Creeks Hydrology Office Report" (USCE, September 1972, revised April 1973). During the Continuation of Planning and Engineering (CP&E) studies, runoff records from 1973 to date were reviewed to determine if any recent floods occurred in the area which were greater than those used in the feasibility reconstitution studies. No greater floods were found. Therefore, the flood reconstitutions developed for the Feasibility Study are considered reasonable and acceptable for use in the CP&E studies.

b. Unit Hydrographs. - The unit hydrographs approved for use in the Feasibility Study were reviewed, using the reconstitution studies mentioned above as a reference. Because no significant changes in the flood

reconstitutions nor in the procedures used to develop the unit hydrographs were necessary, the unit hydrographs developed during the Feasibility Study are considered reasonable and acceptable for use in the CP&E studies.

The Los Angeles (L.A.) S-graph Method was used to develop the unit hydrographs for all of the project area subbasins, shown on Plates H3 and H4 of the Hydrology Appendix. SPF and 200-year flood unit hydrographs were developed for each basin and PMF unit hydrographs were developed for Dry and Fancher Creeks above the proposed reservoir areas. An average foothill S-curve was used for the foothill areas and the L.A. valley S-curve was used for all valley areas. The foothill S-curve was developed from unit hydrographs optimized from the flood reconstitutions discussed in past studies (USCE, June 1973, USCE May 1977). The S-curves, lag relationships, and the unit hydrographs and their parameters, for all of the sub-basins, are shown in the Hydrology Appendix. The n values adopted for use were based on a field inspection of the area and a comparison with values estimated for the gauged areas from the flood reconstitutions. The following n values were used: 0.05 in the foothill areas above the Friant-Kern Canal; 0.2 for the non-urbanized, valley, agricultural areas; 0.05 for the fully urbanized areas (valley); and 0.05-0.2 for the areas that belong in more than one of these categories. The n value for the PMF unit hydrographs for Big Dry and Fancher Creek reservoirs was decreased by 20 percent to reflect the increased hydraulic efficiency of this larger flood.

c. Loss Rates. - The initial and constant loss rate method was used for the CP&E studies. The ground was assumed saturated before the start of the project design storm. Therefore, the initial loss was assumed equal to the constant loss. Greater initial losses are experienced for recontoured agricultural areas not adjacent to mainstream channels. The runoff for these areas, which are downstream of the Enterprise Canal, was assumed to be zero for the first two of the six 5-day waves of the project design storm. The constant loss rates developed for the sub-areas were based on flood reconstitutions in the foothill areas of Dry Creek, the general soil maps prepared by the U.S. Soil Conservation Service for the eastern Fresno Area in 1971, their hydrologic classification of soil series, and a field inspection of the study area. The subarea storm amounts and loss rates are listed in Table H-13, Appendix A.

d. Base Flow. - As presented in the Feasibility Report, a constant base flow of 4 cfs/mi. sq. is used for the main wave of the project design floods. This value results from the flood reconstitutions previously mentioned.

e. Project Storms. - Both cloudburst and general rainstorms were examined to determine the critical type of storm for project design flood computations. The cloudburst runoff from the areas above the project features had higher peak flows but only a fraction of the volume of the general rain floods. The only areas between the Friant-Kern Canal and the proposed features that would produce cloudburst runoff are those narrow subareas immediately adjacent to the stream channels. It thus was determined that the general rain storm covering the entire area produced the most severe flood runoff, peak and volume for the study area.

Two different 96-hour storms were used to develop the project design floods: the Standard Project Storm (SPS) for Big Dry Creek Dam and diversion, and a 200-year storm for the other features. SPS amounts computed previously for Dry Creek were in accordance with the Sacramento District's 1971 Standard Project Rainflood criteria. The time distribution is from the same 1971 report. Table H-14 shows the SPS and 200 year distributions used. The precipitation depths used for the basin subareas are shown in Table H-13, Appendix A.

Storm amounts for the 200-year storm were based on regionalized, four-day rainfall, frequency curves from several recording gauges in and around the project area. Rainfall depths for the different drainage areas were calculated by adjusting the basin mean 200-year depth using the normal annual precipitation (NAP) as a guide. Plate H7 shows the NAP and locations of the stations used. Table H-13 lists both the SPS and 200-year storm amounts for the drainage areas. The time distributions for the storms of December 1938, December 1955, February 1962, and January and February 1969 at the Fresno APNWS station compared favorably with the SPS and 200 year distributions.

f. Flow Frequency Curves. - Feasibility Report flow frequency curves for the Big Dry Creek Reservoir and Dry Creek at Academy stations were updated using twelve additional years of record. The old record spanned the years 1949 through 1978. The new flow frequency curves reflect the water years 1942 through 1983. The procedures used to update the peak flow frequency curve at Dry Creek at Academy generally follow the "Guidelines For Determining Flood Flow Frequency," (Water Resources Council, revised September 1981). Procedures used during CP&E studies to determine the volume frequency curves are found in HEC-IHD-0300, Hydrologic Engineering Methods for Water Resources Development, Volume 3, Hydrologic Frequency Analysis", (April 1975).

Other foothill streamflow records in the area were examined to determine regional variations in mean, standard deviation, and skew. Foothill stream gauges outside the project area which were examined are listed below:

Station	Drainage Area (Sq. Mi.)	Years of Record	Normal Annual Precipitation (Inches)
Fresno River near Knowles	133	66	32.2
Mill Creek near Piedra	127	45	24.6
Dry Creek near Lemon Cove	75.6	22	23.4
Sand Creek near Orange Cove	31.6	20	18.3

This analysis was made primarily for the purpose of developing the duration flow frequency curves for Academy, Big Dry Reservoir and Fancher Creek stations. It was found that there were too few stations and too great of a variation in the statistics to construct any type of isoline patterns for the standard deviation and skew. The statistical means were generally influenced by normal annual precipitation (NAP). The standard deviations increased as the influence of snowmelt and the NAP decreased. The standard deviations ranged from 0.464 (1-day) to 0.369 (30-day) on the Fresno River near Knowles,

to 0.814 (1-day) to 0.700 (30-day) for Dry Creek near Lemon Cove. The skews were negative for all the shorter durations and approached a skew of zero for the Dry Creek at Academy and Sand Creek near Orange Cove gauges for the 30-day curves. These statistical data provided a range of values that were used to develop and evaluate the synthetic duration flow frequency curves prepared for Fancher Creek Reservoir and both Dry Creek duration flow frequency curves. Frequency curves for Fancher Creek Reservoir inflow were derived from relationships developed from the frequency curves on Dry Creek and synthetic floods developed for Fancher Creek Reservoir. The flow frequency curves for Dry Creek at Academy, Big Dry Creek Reservoir inflow, and Fancher Reservoir inflow are shown on Figures H-6, H-7, and H-8 of Appendix A. The statistics for these curves are shown in Table 12 below.

Table 12

Peak and Volume Statistics Developed for Project Frequency Curves

Location	Peak	1-Day	3-Day	7-Day	15-Day	30-Day
Dry Creek at Academy						
Mean	2.652	2.276	2.062	1.86	1.683	1.550
Standard Deviation	.585	.573	.535	.503	.471	.449
Skew	-.30	-0.20	-.20	-.10	0.0	0.0
Big Dry Creek Reservoir Inflow						
Mean	N/A	2.326	2.114	1.929	1.760	1.602
Standard Deviation	N/A	.640	.620	.592	.576	.562
Skew	N/A	-.20	-.20	-.20	-.20	-.20
Fancher Creek Reservoir Inflow						
Mean	2.330	1.952	1.735	1.532	1.342	1.041
Standard Deviation	.600	.573	.514	.501	.493	.461
Skew	-.20	-.20	-.20	-.20	-.20	-.20

A comparison of the updated peak flow frequency curves with those in the Feasibility Study shows no significant change between the two. The resulting project and pre-project peak flows of the two studies are compared in Table H-20. However, the longer volume duration curves did change. The 7 through 30-day, 200-year volumes decreased; the updated curves have a lower mean and smaller deviation. The updated volume duration curves for Big Dry and Fancher Creek reservoirs, along with a more detailed system operation plan, resulted in smaller required storage space to control their respective project floods.

Peak flow curves for Alluvial Drain, Pup Creek, and Redbank Creek detention basins at or just below the detention basins did not change from the Feasibility Report. Thus, these curves were used during CP&E studies.

28. Project Design Floods. - A 30-day, six-wave, SPF was developed for Big Dry Creek Reservoir and a 200-year flood series was developed for the detention basins and Fancher Creek Reservoir. For the SPF, the main 5-day wave was computed by using the 96-hour project storm and the HEC-1 basin

model developed to analyze project conditions. The remaining five waves were developed using ratios of the main wave. These ratios were obtained from volume flow frequency curves developed for the Dry Creek at Academy gauge. The ratios of the six 5-day waves to the main wave for the Big Dry Creek Reservoir SPF are 0.130, 0.203, 0.387, 1.000, 0.219, and 0.136. The ratios of the six 5-day waves to the main wave for the 200-year flood for Redbank and Fancher creeks are 0.143, 0.221, 0.513, 1.000, 0.239, and 0.148. The 30-day series hydrographs are shown on Figures H-9 through H-17 in Appendix A.

a. Big Dry Creek Dam Spillway Design Flood. - Spillway design flood (SDF) studies for Big Dry Creek were originally performed in 1944 in conjunction with the preparation of a Definite Project Report (DPR) on the flood control improvement. These studies used a 72-hour Probable Maximum Storm Precipitation (PMP) based on criteria from "Hydrometeorological Report No. 3 Maximum Possible Precipitation over the Sacramento Basin" (US Weather Bureau, May 1942) which produced a depth of 13.0 inches of rain and 5.0 inches of water equivalent of antecedent snow cover. Ratios of NAP were used to apply the Sacramento Basin PMP to the Big Dry-Dog Creek area. The resultant SDF had a peak flow of 17,000 cfs and a volume of 66,800 acre-feet. The SDF was subsequently revised and presented in "Big Dry Creek Reservoir and Diversion Hydrology Office Report" (USCE, June 1973). The revised PMP amounts were obtained by methods and criteria presented in "Hydrometeorological Report No. 36, Probable Maximum Precipitation in California," (U.S. Weather Bureau, October 1961, revised October 1969). The revised 72-hour PMP amount is 21.3 inches (it was assumed that a previous storm melted the snow), and the resultant SDF had a peak flow of 45,000 cfs and a volume of 67,800 acre-feet. In 1980, the Sacramento District completed a spillway adequacy study on Big Dry Creek Dam, "Big Dry Creek Dam and Diversion Probable Maximum Flood Study," (USCE, July 1980). The results of this study agreed with the findings of the 1973 office report. These studies assumed that all the PMF flow from Big Dry and Dog Creek entered the reservoir.

For CP&E studies a PMF was calculated for Dry Creek and Dog Creek basins using the updated HEC-1 basin model. These PMF's were combined and routed into Big Dry Reservoir. PMF unit hydrographs and routing data used for this analysis are shown in Table H-12. The 1980 and current Dry Creek studies showed approximately the same results, a peak inflow of 45,400 cfs and a volume of 66,800 acre-feet as presented in Table 13. The Dog Creek (at the Dog Creek Diversion to Big Dry Creek Reservoir) peak inflows and 72-hour volumes differed slightly. Present studies show a peak of 12,000 cfs with a 72-hour volume of 13,800 acre-feet, compared to the previous study peak of 11,700 cfs and a 72-hour volume of 14,200 acre-feet.

b. Fancher Creek Dam Spillway Design Flood. - The PMP amounts developed for estimating the Fancher Creek Reservoir inflow were obtained by methods and criteria presented in the 1969 "Hydrometeorological Report No. 36." Floods for both the 6-hour cloudburst and the 72-hour general rain were computed. The 72-hour flood was used because it produced the more severe combination of peak and volume. The same methods used in the Feasibility Study were used herein to derive the PMF. The present PMF inflow to Fancher Creek Reservoir has a peak of 20,600 cfs and coincidentally a 72-hour volume of 20,900 acre-feet. The Fancher Creek PMF presented in the Feasibility

Report has a peak of 19,200 cfs with a volume of 17,600 acre-feet. The difference is caused by the increase in PMP amounts from a basin average of 18.2 inches to 21.2 inches.

All precipitation amounts used in this study are shown in Table H-4 . A comparison of the PMF runoff derived during the Feasibility Study and the CP&E Study is shown in Table 13.

29. Hydrologic System Analysis. - The computer program HEC-1 "Flood Hydrograph Package" was used to model the complex interrelationship of creeks and canals and runoff conditions of the study area during the SPF and 200-year design flood events. The model is described in the Hydrology Appendix and shown on Plate H5. The model was developed to verify preproject flows and volumes assumed for the Feasibility Study, to aid in refining the sizes of the project features, and develop a system operation plan.

a. Subareas. - Modeling a hydrologically complex basin like the Redbank and Fancher creeks project area requires the basin to be broken down into subareas. The project area was divided into many small sub-areas using artificial and natural physical features such as canal crossings as key locations for flow computations. The agricultural areas below the Friant-Kern Canal, some which were recontoured, have no defined drainage channels and were separated from those drainage areas immediately adjacent to the mainstream channels. Subarea boundaries are shown on Plates H3 and H4 in the Hydrology Appendix.

Table 13

Probable Maximum Flood Runoff Comparisons

Inflow Location	Peak Flow		72-Hour Volume	
	Feasibility Study (cfs)	CP&E (cfs)	Feasibility Report (acre-feet)	CP&E (acre-feet)
Big Dry Creek Reservoir	45,000	45,400	67,800	66,800
Dog Creek Diversion to Big Dry Creek	11,700 1/	12,000	14,200 1/	13,800
Fancher Creek Reservoir	19,200	20,600	17,600	20,900

1/ From July 1980 Study

b. Routing Methods. - The Muskingum and Modified Puls routing methods were used to convey water through hydraulic constrictions, streams, canals, and overland areas. The Muskingum routing method was used for canals with little variance in cross-sectional area and velocity (storage - discharge is linear). The Modified Puls routing method was used for streams, canals, and overbank flood areas with great variability in cross-sectional area and velocity (the storage-flow relationship is nonlinear). Pertinent Muskingum and Modified Puls data is shown in Tables H-16, H-17, respectively, in Appendix A.

The majority of the storage-discharge data used in the Modified Puls routings were derived from the Fresno Flood Insurance Study (USCE, 1979). In areas where storage-discharge data were not available, they were developed from field surveys and hydraulic analyses.

c. Model Assumptions. - The following assumptions were made when running the HEC-1 project basin model.

(1) Flood Flow Volumes. - No flood flows from drainage areas above the Friant-Kern Canal (that drain under or over the Friant-Kern Canal) will enter that canal.

(2) Canal Banks. - No canal bank in the study area will fail when overtopped. Any flow in excess of a channel capacity will spill out and go overland until it is intercepted by another channel.

(3) Canal Operations. - As soon as flood runoff starts to enter the canals, all flow from Holland Creek will be diverted to the Kings River and all restrictions in the Gould and Enterprise Canals, such as boards and gates, will be removed or opened fully to move water out of the system as rapidly as possible.

(4) Gould Canal. - The only flow entering the Gould Canal originated from subareas below the Enterprise Canal. During high flow periods inflow from Mud Creek and adjacent subareas will cause the Gould Canal to overtop between Mud Creek and Redbank Creek. Flows up to 70 cfs will be diverted to the Fresno Canal through the Vernon Ditch (upstream of Fancher Creek) when the Gould Canal is flowing between 130 to 200 cfs. This assumption made for the model will be a project sponsor requirement. All flow in excess of the Gould Canal capacity of 200 cfs is routed overland to Fresno Canal. A regulated siphon at Redbank Creek further controls flow in the canal below Redbank Creek to 150 cfs or less.

(5) Enterprise Canal. - As with the Gould Canal, Mud Creek and adjacent subarea flood flows are assumed to spill into the Enterprise Canal during high flow conditions. When the canal's capacity is exceeded at Mud Creek, the water spilling over the canal bank will continue downstream in the Mud Creek Channel. Any excess flow spilling out of the Enterprise Canal between Mud Creek and Fancher Creek will flow overland until it is intercepted by the Gould Canal.

Under project conditions, Enterprise Canal flows were assumed to be diverted into Fancher Creek in accordance with the Selected Plan, presented in this GDM. This diversion and adequate Fancher Creek capacity will be a project sponsor requirement. The flows that occur in the canal between Fancher and Redbank Creeks will be from local runoff. Project flood flows will not exceed channel capacity in the reach from Fancher Creek to Dry Creek. The Enterprise Canal siphon under Dry Creek will be controlled so that flows in excess of 90 cfs will spill down Dry Creek to the Herndon Canal.

(6) Fresno Canal. - All flows entering the Fresno Canal remain in the Fresno Canal channel or the immediate overbank area and continue

downstream to The Fancher Creek - Mill Ditch headworks. The Fresno Canal ends at this point and continues downstream as the Fancher Creek Canal.

(7) Mill Ditch. - The Mill Ditch headworks' gates were assumed to be closed to Mill Ditch for the entire flood. The only flows entering Mill Ditch from the Fresno Canal will be those in excess of 770 cfs. This is the estimated channel capacity of Fancher Creek Canal at the Headworks. The flows over 770 cfs were divided in half in the model, half spilling over the headworks and into Mill Ditch and the remaining half continuing down Fancher Creek Canal. Flows in Mill Ditch are combined with the outflow from the Redbank Creek Detention Basin and routed to the junction of Dry Creek and Herndon Canal. Total flows into Herndon Canal were estimated by combining all routed flows from Dry Creek, including the flows from the Enterprise and Gould canals and Mill Ditch.

(8) Mud Creek. - Runoff from this basin was routed through the restricting hydraulic structures at Friant-Kern Canal and Enterprise Canal. Mud Creek enters Gould Canal unrestricted. Runoff from Mud Creek during the project design flood was assumed to cause overtopping of the Gould Canal levees between Mud and Redbank Creeks. The excess runoff was routed overland to the Fresno Canal.

(9) Big Dry Creek Reservoir, Local Areas. - Hydrographs for all local areas located above the Friant-Kern Canal, that drain into the reservoir or contribute flow to the Little Dry Creek diversion channel below the reservoir, are routed over/under the canal before being combined. The Dry Creek inflow hydrograph was routed through the reservoir using the Modified Puls method, then combined with the local area contributing flows to the Little Dry Creek outlet channel. All flow in excess of 700 cfs was diverted through the wasteway in the Little Dry Creek diversion levee. During the SPF, no flows went through the wasteway structure.

(10) Local Area Below Big Dry Creek Reservoir. - No flow releases were made from the reservoir at the Dog Creek outlet works or Big Dry Creek outlet works during the project design flood routings. All local flow is routed into Dog Creek and Dry Creek, downstream of Big Dry Creek Reservoir, and moved downstream to the boundary of the project area.

30. Sedimentation and Erosion. -

a. Erosion. - The San Joaquin hydrologic basin has moderate to severe erosion problems. Generally, sheet and gully erosion affect the foothills and mountains while wind erosion and poorly managed agricultural practices affect the flat valley floor regions. Although the contributing area is extensive, the sediment yield from the valley floor is quite low (SCS, November 1977). In the foothills and mountains, sheet and gully erosion can be a major problem. However, foothill areas east of Fresno experience far less sheet and gully erosion problems compared to other foothill regions in the San Joaquin Valley.

The vegetative cover on range and forest land is generally good in the Sierras. Agricultural uses of the drainage areas above the Big Dry and Fancher Creek reservoir sites are almost exclusively grazing. This range

land is well managed and not overgrazed. Supplemental seeding programs are implemented in the Fall to help decrease erosion while providing extra feed for the cattle.

b. Sedimentation. -

(1) General. - The report, "San Joaquin Valley Basin Study, California" (SCS, Nov. 1977), presented average sediment yield for five broadly defined areas in the San Joaquin Valley Basin, Plate H8. Average sediment yields were determined for regional areas delineated in the SCS report and by applying the Corps' Universal Soil Loss Equation to the regional areas pertaining to the Redbank and Fancher creeks project. Table 14 presents an average annual sediment yield and an expected range for the annual yield for regional areas within the San Joaquin Valley Basin.

Table 14

San Joaquin Valley Basin
Estimated Sediment Yields

Regional Area	Estimated Average Annual Sediment Yield	Expected Range in the Annual Yield
	(Acre-Feet per Square Mile per Year)	
East side of Coast Range & Tehachapi Mts.	0.30	0.20-0.50
West Side Fans	0.15	0.10-0.20
Central Valley	0.05	0.00-0.10
East Side Fans	0.20	0.10-0.20
Sierra Nevada Mountains	0.25	0.10-0.30

Source: SCS, Nov. 1977

(2) Reservoir Sedimentation. - Plate H8 shows a table of reservoir sedimentation for the east side of the San Joaquin River basin and a map showing the locations of these sediment reaches. These data were used to estimate reservoir sedimentation. They are a compilation of data from the SCS November 1977 report and "Sediment Deposition in U.S. Reservoirs - Summary of Data Report through 1980," (USGS, May 1983). The average annual sediment yield for these east side reservoirs is 0.15 AF/mi^2. Based on a visual inspection of the project area and basin sediment yield data, the estimated average annual yield of 0.15 AF/mi^2 for Big Dry Creek and Fancher Creek reservoirs is reasonable.

The area between the Friant-Kern Canal and the proposed detention basins is zoned agricultural or rural residential and is characterized by flat slopes and leveled fields. During the Feasibility Study the sediment yield for areas above the Redbank Creek, Pup Creek, and Alluvial Drain detention basin sites was assumed to be 0.05 AF/mi^2 per year. To confirm this sediment yield estimate, the Department of Civil Engineering, California State University, Fresno, under contract with the COE in 1983, took suspended load sediment samples at three locations on Redbank Creek during high water periods. The estimated average suspended sediment load from these samplings

for all events was less than 0.01 AF/mi^2. Thus, 0.05 AF/mi^2 is considered to be a conservative and reasonable value. The 100 year reservoir and detention basin sediment accumulation due to these sediment yields are shown in Table 15. The average annual sediment accumulation for Redbank Creek and Pup Creek detention basins is about 2.8 cy. Alluvial Drain Detention Basin has an average annual sediment accumulation of about 3.2 cy. However, it is expected that the majority of the sediment would be deposited in the basins by large infrequent flows.

The trap efficiency value for Redbank Creek Detention Basin shown in Table 15 is thought to be conservative because: (1) the channel invert is below the basin invert and the only bed load deposition would occur in the channel, (2) sediment samples from drill logs taken in the area are 60% sand and 40% fines, and thus only a portion of the fines that were suspended would

Table 15

100-Year Reservoir and Detention Basin Sediment Accumulation

Reservoir	Drainage Area (Sq.mi.)	Contributing Area (Sq.mi.)	Annual Sediment Yield ($AF/mi^2/YR.$)	Trap Efficiency (%)	100 year Sediment Accumulation (Ac-Ft)
Big Dry Creek	81.68	78.60	0.15	95	1,120
Fancher Creek	27.83	27.83	0.15	95	396
Detention Basin					
Redbank Creek	25.17	11.30	0.05	20	11.3
Pup Creek	4.26	2.32	0.05	95	11.0
Alluvial Drain	2.65	2.65	0.05	95	12.6

enter the detention basin, and (3) over half of the daily flows from Redbank Creek will stay in the channel and not enter the basin area.

(3) Reservoir Sediment Distribution. - Estimates of the sediment distribution in Big Dry Creek and Fancher Creek reservoirs were made using the pool elevation - duration method discussed in ETL-1110-2-64, (7 July 1969). This empirical method attempts to account for the influences of reservoir regulation inherent in a pool elevation-duration curve, general effects of the fraction of sand materials involved, and the size and shape of the reservoir. The approach is based upon the assumption that pool elevation and size characteristics of the sediment are two of the most important factors influencing deposition in given elevation zones. It also assumes that: 1) over a long period of time, sediment delivered by medium and moderate floods will establish some statistical order of coincidence with pool elevations between the maximum and minimum, and 2) that regulation of the rare floods (and therefore, the distribution of sediment deposited in the higher elevation zones) will be similar. This suggests that there may be some reasonably definable relationships between duration of a given pool and the amount of sediment that will be deposited above and below the elevation of that pool.

The results of the sediment distribution analysis are shown in Tables 16 and 17 in terms of accumulated sediment volume. Figures H-1 and H-2 in the Hydrogology Appendix show pool elevation-duration and sediment deposition as percentages versus pool elevation in feet for the Big Dry Creek and Fancher Creek Reservoirs, respectively. These curves were instrumental in developing the data in Tables 16 and 17. The pool elevation-duration curves represent the percent of time in which the pool is at or above a given elevation. The sediment deposition curve shows the percent of the total 100 year sediment volume that will be deposited at or below a given elevation. As shown in Table 15, the reservoirs have an assumed trap efficiency of 95 percent.

(4) Channel Sedimentation. - Field investigation of the channels downstream of existing reservoirs and detention basins in the project area indicate no significant erosion or deposition problems; it is expected that problems will not occur under project operation. An exception may be Redbank

Table 16

Reservoir Sediment Distribution and Storage Capacity
Big Dry Creek Reservoir

Elevation	Initial Reservoir Capacity (Ac-Ft)	100 Yr Sediment Volume (Ac-Ft)	Final Reservoir Capacity (Ac-Ft)
396	0	0	0
400	216	40	176
405	956	120	836
410	2,399	240	2,159
415	5,139	420	4,719
420	9,777	710	9,067
425	16,473	980	15,493
430	25,184	1,090	24,094
433.2	31,785	1,120	30,665

Table 17

Reservoir Sediment Distribution and Storage Capacity
Fancher Creek Reservoir

Elevation	Initial Reservoir Capacity (Ac-Ft)	100 Yr Sediment Volume (Ac-Ft)	Final Reservoir Capacity (Ac-Ft)
454	0	0	0
460	250	33	217
465	1,160	120	1,040
470	2,861	230	2,631
475	5,595	350	5,245
480.5	10,304	396	9,908

Creek at the gated control structure of the Redbank Creek Detention Basin. The creek may be capable of carrying sufficient sand load to interfere with proper operation of the automatic gates which are sensitive to tailwater fluctuations. Further study of the creek may be accomplished during preparation of the Feature DM for this facility to identify if a problem exists and define possible solutions, such as an upstream sediment trap, if needed.

31. Reservoir Sizing. -

a. Big Dry Creek Reservoir. - Big Dry Creek Reservoir was sized to provide SPF protection. The total initial storage capacity (gross pool) required 31,785 acre-feet at elevation 433.2, (30,665 for water and 1,120 acre-feet for sediment). This storage requirement was determined by routing the SPF series through the reservoir. The reservoir was sized based on an operation similar to that for the existing project; encroachments on the flood control space were released as rapidly as possible without causing damage downstream of the project. All releases during the reservoir design flood were made through the Little Dry Creek outlet to allow the downstream channels on Dog and Dry Creek to pass local flow. Releases to the Little Dry Creek Diversion channel were controlled so that the release plus the local flow would not exceed 560 cfs, (reflecting an operating contingency of 20 percent of the 700 cfs downstream capacity). Also, a forecast error allowance of 25 percent was used to compute the local flow into the Little Dry Creek Diversion channel. The project design flood routing is shown on Plate B8.

b. Fancher Creek Reservoir. - Fancher Creek Reservoir was sized to provide 200-year flood protection. Gross pool was determined to be 10,304 acre-feet with a corresponding maximum water surface elevation of 480.5 based on the 200-year flood series. The outlet works were assumed to be ungated and release 100 cfs at gross pool. The project design flood routing is shown on Plate F3.

c. Pup Creek Detention Basin. - Pup Creek Detention Basin was sized to provide 200-year flood protection. The 200-year flood required 495 acre-feet of storage capacity. The corresponding maximum water surface elevation was 376.8. The storage requirement was determined by routing the 200-year flood series through the basin. The outlet works were assumed to be ungated and to release 25 cfs at gross pool. The project design flood routing is shown on Plate P2.

d. Alluvial Drain Detention Basin. - Alluvial Drain Detention Basin was sized to control a 200-year flood. The storage requirement was determined by routing the 200-year flood series through the basin. The 200-year flood required 385 acre-feet of storage capacity. The corresponding maximum water surface elevation during the design event was 386.4. The outlet works was assumed to be ungated and to release 25 cfs at gross pool. The project design flood routing is shown on Plate A2.

e. Redbank Creek Detention Basin. - Redbank Creek Detention Basin was sized to provide 200-year flood protection. The 200-year flood required 940 acre-feet of storage capacity. The corresponding maximum water surface

elevation was 349.3. The storage requirement for Redbank Creek Detention Basin was determined by routing the 200-year flood series through the Redbank and Fancher creek stream system. The outflow from Redbank Creek Detention Basin was assumed to be controlled by automatic gates which allow all inflow of 200 cfs or less to pass directly through the basin. Thus, the volume of water stored increases when Redbank Creek inflow exceeds 200 cfs and decreases when inflow drops below 200 cfs. The project design flood routing is shown on Plate R3.

32. Tailwater Rating Curves. - With the exception of the impact type energy dissipator for the Big Dry Creek outlet works, the tailwater rating is an important aspect of stilling basin design. The tailwater curves shown on Plates B8, F4, P2, A2, and R3 were developed using available aerial topography and the HEC-2 water surface profile computer program. The manning n-value used in the backwater computations was 0.035. For Feature Design Memorandum work the aerial topography will be supplemented by surveyed cross-sections to establish actual invert elevations at Fancher Creek Dam, Big Dry Creek Dam, and Redbank Creek Detention Basin. For Fancher Creek Dam, the stilling basin design was completed prior to the aerial topography; therefore the current design reflects a tailwater based on normal depth computations.

33. Hydraulic Design of Discharge Facilities. -

a. Functional Criteria. -

(1) Functional Criteria for the System. - The basic purpose of the project is to intercept all stream flows in excess of downstream channel capacities and hold such flows until the peak of the storm has passed and downstream channel capacities are again available to carry nondamaging flows. More specifically, the project is designed to allow the portion of the watershed below the Friant-Kern Canal (including the urbanized area) to be drained first through the existing streams and canals. Big Dry Creek Reservoir is designed to retain the flows generated above the Friant-Kern Canal long enough so they can be released without causing downstream flooding. Flows intercepted by Fancher Creek Reservoir are to be released at a greatly reduced rate through an ungated outlet.

Other than flows intercepted by Big Dry Creek Dam, most flood flows in the Fresno-Clovis Metropolitan area are routed through the Herndon Canal to the San Joaquin River. Thus, the capacity of the Herndon Canal, 500 cfs between the Enterprise Canal and Dry Creek, is a major limiting factor on the total maximum allowable outflow from the proposed project features to the San Joaquin River.

The current Big Dry Creek Reservoir operating procedures will not change. The majority of the flood flows will continue to be diverted to the San Joaquin River. The maximum allowable release will be 700 cfs. Both Pup Creek and Alluvial Drain, however, are tributaries to Dry Creek and must utilize that channel to carry away releases from the proposed detention basins. When these releases are added to the urban drain discharges which must be made into Dry Creek, total downstream flows exceed the creek's safe discharge capacity of 150 cfs above the Gould Canal. This requires diversion

of some Dry Creek flows into the Herndon Canal for transport to the San Joaquin River.

The peak releases for the detention basins were established to permit the various parts of the Fresno-Clovis urban drain system to be discharged simultaneously and thus maximize the level of flood protection available to both the urban and rural areas. Based on downstream channel capacities and expected local runoff during the 200 year design event, the maximum allowable outflow from the Pup Creek and Alluvial Drain detention basins was determined to be 25 cfs each.

The proposed Fancher Creek Dam will intercept and detain the flows from Fancher Creek, Hog Creek, and several tributaries to Redbank Creek. Local inflows to Fancher Creek can be substantial. To reduce downstream volumes and peak flow, because of limited channel capacity, Fancher Creek Dam outlet works was designed to release 100 cfs at gross pool.

Redbank Creek Detention Basin is designed to work in conjunction with Fancher Creek Dam, maintaining a flow of 200 cfs or less in Mill Ditch at Temperance Avenue just below Redbank Creek Detention Basin during the design flood. Temporary peak flows at Temperance Avenue are expected to be as high as 280 cfs due to local inflow above Temperance Avenue. This allows for the disposal of local flows and urban drainage into Mill Ditch, Dry Creek, and Herndon Canal downstream from Temperance Avenue, up to a sustained rate of 300 cfs.

(2) Functional Criteria for Establishing Top of Dams. - The top of Big Dry Creek and Fancher Creek dams were established by routing the PMF for each dam and adding appropriate freeboard to the resulting maximum pool elevation. Following the procedures of EC 1110-2-27 (Policies and Procedures Pertaining to Determination of Spillway Capacities and Freeboard Allowances for dams) routings were initiated at gross pool storage (spillway crest elevation) and 50 percent of gross pool storage, with respective freeboard allowances of 3.0 and 5.0 feet. The routings indicated the difference in maximum pool elevation to be 1.0 feet for Fancher Dam and 0.2 feet for Big Dry Creek Dam. With the addition of 5.0 feet of freeboard, the initiation of the PMF at 50 percent of gross pool would be the more critical condition. However, 5 feet of freeboard was considered unwarranted both from a safety and economic viewpoint. Therefore, the top of dam was established by routing the PMF initiated at gross pool and adding 3.0 feet of freeboard. The selected freeboard exceeds the specific wind generated design wave runup heights for both dams.

(3) Functional Criteria for Spillway Design. - The spillways for Fancher Creek and Big Dry Creek dams were designed to safely pass the PMF. Routings were accomplished using the modified - Puls method. The gated outlet works on Big Dry Creek Dam was assumed non-functional during the PMF, whereas the ungated outlet works on Fancher Creek Dam was assumed to be functional. An economic evaluation of spillway width versus top of dam established spillway width. For Big Dry Creek Dam both an ogee and broadcrested spillway were investigated. The ogee spillway, located at the existing spillway site, proved to be more economical than a relocated broadcrested spillway. For Fancher Dam the spillway must pass through the

embankment and, therefore, an ogee spillway was selected. The spillways were designed in accordance with draft EM 1110-2-1603, (Hydraulic Design of Spillways). The maximum head on the crest during the PMF was taken as the design head.

The detention basins were sized incorporating a maximum of 3 feet of retention embankment without freeboard allowance. The embankments will be protected by soil cement so that overtopping during events which exceed the 200-year design event will preclude the possibility of erosive failure. Therefore, no spillways are considered to be required for the detention basins.

(4) Functional Criteria for Outlet Works. - From reservoir regulation studies, the outlet works were designed to safely pass the required discharge during the design flood event without exceeding downstream channel capacity. For the detention basins and Fancher Creek Dam the gated outlet works would reduce evacuation time which would lower embankment seepage amounts. For Redbank Creek Detention Basin, a gated control structure would significantly reduce basin size and reduce evacuation time. However, in all cases but Redbank Creek Detention Basin, reduced costs and operational simplicity resulted in selection of ungated outlet works. For Redbank Creek Detention Basin, releases would be controlled by automatic, constant downstream water surface level gates which would operate similarly to an ungated headworks. The two outlets for Big Dry Creek Dam are presently gated and will remain gated under the proposed project.

The outlet works and conventional stilling basins were designed in accordance with EM 1110-2-1602 (Hydraulic Design of Reservoir Outlet Works). Because the maximum release from the Big Dry Creek outlet works is only 150 cfs, an impact energy dissipator was selected and designed in accordance with U.S. Bureau of Reclamation Report No. HYD 572. A cost comparison during Feature DM work will be made between an impact basin and a conventional stilling basin. For Alluvial Drain and Pup Creek detention basins, energy dissipation would be provided by a rock lined basin designed from guidance provided in HDC 722-6 (Storm Drain Outlets). For riprap design downstream of the energy dissipators the minimum W-50 size was obtained from HDC 722-7 (Storm Drain Outlets). The appropriate layer thickness and gradation for the minimum W-50 was selected from Enclosure 3 of ETL 1110-2-120 (Guidance for Riprap Channel Protection).

b. Big Dry Creek Dam. -

(1) Spillway. - The spillway at Big Dry Creek Dam is designed to safely pass the PMF. The spillway crest elevation was set at the design flood maximum pool elevation (gross pool) and the top of the dam embankment was set at 3.0 feet above the PMF maximum pool. The maximum PMF inflow to Big Dry Creek Reservoir is 45,400 cfs. The resulting maximum spillway discharge and corresponding flood pool elevation will be 33,400 cfs and 439.6, respectively. The PMF routing and spillway rating curves are shown on Plates B7 and B8, respectively. During the PMF routing both outlet works gates were assumed to be closed and the routing was initiated at gross pool, elevation 433.2.

(a) Approach Channel. - The spillway approach channel will be modified to a trapazoidal shape. The width at the spillway crest elevation of 433.2 will be 560 feet, side slopes 1V on 2H, and the resulting bottom width at the existing invert elevation of 424.0 will be 523.2 feet. Concrete abutment walls with radii of 15 feet will provide the transition from the trapezoidal approach channel to the rectangular spillway section. The left side of the approach channel will be excavated to maintain a bottom width of 523.2 feet and meet the existing channel invert elevation upstream.

(b) Ogee Crest. - The upstream face of the new ogee section will coincide with the upstream edge of the existing broadcrested sill. The existing sill will be removed. The new spillway crest elevation was set at the design SPF pool elevation of 433.2. The maximum spillway design flood (PMF) inflow is 45,400 cfs and the resulting maximum spillway discharge will be 33,400 cfs. The maximum spillway design flood pool elevation will be 439.6. The ogee crest was designed according to HDC 111-2/1 (Ogee Spillway Crest) for a head of 6.4 feet and will terminate on a slope of 1V on 0.8H. A toe radius of 15 feet will provide a transition from the ogee crest to the stilling basin apron and was based on an equation presented in "Open Channel Hydraulics" (Chow, 1959). The discharge coefficients of the low ogee were taken from HDC 122-1 (Low Ogee Crest Discharge Coefficients) and have an approach depth to design head (P/H) ratio of 1.33.

(c) Stilling Basin. - The stilling basin for the Big Dry Creek Dam spillway was designed in accordance with Draft EM 1110-2-1603 (Hydraulic Design of Spillway) for a tailwater to sequent depth ratio (TW/D2) of 1.0, chosen to reflect the short exit channel length. The basin length was set at 3.0 D2. The basin will be 31.0 feet long and 550 feet wide with an apron elevation of 419.9. Two rows of baffle blocks will be provided. Baffle block height, width, and spacing were set at 1.75 feet, approximately the entering flow depth (D1). The first row of baffles was set at 15.5 feet, approximately 1.5 D2, from the start of the basin. The second row of baffles was placed at approximately 0.5 D2 or 5.2 feet downstream of the first row. The end sill will be 0.85 feet high or approximately 1/12 D2. The adverse channel slope downstream from the endsill will begin at 0.85 feet below the endsill. The stilling basin top of wall was set at least 3.0 feet above the D2 elevation.

(d) Spillway Exit Channel. - From 1984 aerially surveyed topography of the existing spillway, the existing exit channel slope, although originally designed to be supercritical, actually increases in the downstream direction from subcritical to supercritical. The tailwater elevation for the design discharge of 33,400 cfs was computed from a backwater initiated at critical depth which occurs 500 feet downstream of the ogee crest. Because critical depth for lower discharges occurs slightly further downstream, the exit channel will be widened to 560 feet from the stilling basin end sill downstream 550 feet. From a point 550 feet downstream from the end sill, the spillway exit channel will converge on a 1 on 10 angle from each side until the toe of cut for the improved exit channel width matches the toe of cut for the existing exit channel. Using a Manning n-value of 0.035, the tailwater elevation was computed to be 429.8 for the design discharge. The exit channel will have an adverse slope of 1V on 10H for approximately 24 feet from the downstream end of the stilling basin end

sill to where it intersects the existing exit channel invert, elevation 422.3. The next 550 feet of exit channel (the existing subcritical reach) will have side slopes of 1V on 2H and a 560-foot bottom width. Exit channel velocities on the adverse and subcritical slopes will range from 6 to 12 fps. To insure that the required tailwater for proper stilling basin performance will be developed and retained over time, a concrete grade-control sill will be constructed in the exit channel 500 feet downstream from the ogee crest. The sill will extend a maximum of 20 feet below the channel invert, or to bed rock, whichever is less. Riprap from the stilling basin end sill to the adverse channel section will be provided on the bottom and side slopes. Beyond the exit channel, spillway discharges will be contained and directed by the natural topography. The proposed spillway modifications will not change flow paths in this area from those of the existing spillway.

(2) Big Dry Creek Outlet Works. - The outlet works on Dry Creek is designed to provide beneficial downstream water use without exceeding the downstream channel capacity of 150 cfs between the dam and Herndon Canal. The outlet works gate was assumed to be closed during flood control operations. The outlet works was sized to the minimum acceptable dimensions for inspection purposes and has a design discharge capability of 150 cfs at pool elevation 415.0. To limit discharge to 150 cfs gate operation will be required. Flow downstream from the gate will be open channel.

(a) Approach and Intake. - The approach channel for the Big Dry Creek outlet works will be 31.2 feet long, extending from the upstream toe of the embankment to the control tower inlet. The invert of both the approach channel and the tower inlet will be set at elevation 400.0. Elliptical side wall and roof curves will be provided at the intake. The side wall curves have an x-dimension of 1.0 times and a y-dimension of 0.33 times the gate passage width of 3.0 feet. The elliptical roof curve will have an x-dimension of 1.0 times and a y-dimension of 0.67 times the gate passage height of 3.0 feet. The trashrack at the inlet will be 5 feet wide and 6.0 feet high with a bar spacing of approximately 2/3 of the conduit dimensions. Because the control tower is recessed into the embankment, requiring an approach channel formed by retaining walls, the trashrack will be inset between the walls at a 45 degree angle. The average velocity through the trashrack will be 4 fps.

(b) Tower and gates. - The 53.6-foot tall, 13.00 by 13.25-foot control tower will be constructed of reinforced concrete. The tower will be completely enclosed above the conduit and will be kept dry at all times. Drainage for the control shaft chamber floor will be provided. The tower will house a set of tandem emergency and service gates and their operating mechanisms to regulate releases into the conduit.

The control gates will be 3.0 foot square wedge lock slide gates. The upstream gate will act as the emergency gate and the downstream gate as the service gate. The gates will be housed in covered slots in the floor of the shaft, above the conduit. Wedge lock type gates are considered the most practical type for the required service because of their suitability for operation under a partially open condition, practicability for making fine adjustments required for flow regulation, simplicity of design and control,

low potential for obstruction, low potential for damage by flow of debris through the gate opening, and comparatively low maintenance cost. Air will be supplied to the top of the conduit, immediately downstream from the service gate, by a six-inch diameter air-intake pipe. The air intake will be positioned above the maximum pressure head expected in the conduits. The air vent was sized in accordance with HDC 050-1 and was conservatively based on an 80 percent gate opening at gross pool elevation 433.2 and an air flow velocity of 150 fps.

(c) Conduit. - The 188.2-foot long reinforced concrete outlet works conduit will be 3 feet wide and 3 feet high. The conduit will be steel lined from the emergency gate to 5 feet downstream of the service gate to minimize the possibility of cavitation damage when flows are regulated by small gate openings. The invert elevation will be at 400.0 and the conduit slope will be 0.02954. The conduit will have a horizontal slope for 3.0 feet upstream of the exit and an invert elevation at the exit of 394.5.

(d) Energy dissipator. - The outlet works conduit will discharge into an impact basin, designed in accordance with U.S. Bureau of Reclamation Report No. HYD 572. The conduit invert elevation at the basin inlet will be 394.5. The basin was designed for a maximum discharge of 150 cfs at gross pool elevation 433.2. Basin dimensions are a function of the Froude number of the flow entering the basin. The Froude number, as defined by USBR, was computed by forewater computations from the vena contracta of the slide gate to the conduit exit and was found to be 3.0. The impact basin will be 12.0 feet wide and 17.0 feet long. The exit channel will be excavated to 18.0 feet wide at the end sill and taper to 14 feet at a 1 on 10 angle. The exit channel will be riprapped, side slopes and bottom, for 20 feet downstream of the end sill.

(3) Little Dry Creek Outlet Works. - The outlet works on Little Dry Creek was designed for a flood release of 700 cfs at pool elevation 416.4 based on an optimization of reservoir size. The outlet works will be gated to limit the maximum flood release at higher pool elevations to 700 cfs, the existing downstream channel capacity. Plates B4 and B5 show the plans and sections for the Little Dry Creek outlet works. Plate B8 shows the tail-water rating curve.

(a) Approach and Intake. - The approach channel for Little Dry Creek outlet works will be 18.3 feet long, extending from the intersection of the upstream slope of the embankment to the control tower inlet. The channel invert will be set at elevation 403.0. Elliptical side wall and roof curves will be provided at the conduit intake. The side wall and roof curves will have an x-dimension of 1.0 times and a y-dimension of 2/3 times the gate passage width of 3.0 feet and height of 6.5 feet, respectively. The inlet trashrack will be 15 feet wide with horizontal and vertical bar spacing based on approximately 2/3 of the gate passageway dimensions. As with Big Dry Creek outlet works, the trashrack will be inset between the approach channel retaining walls at a 45 degree angle, for a total length of approximately 17.0 feet. The average velocity through the trashrack will be about 3 fps.

(b) Tower and Gates. - The 50.6 foot tall, 13.25 by 17.00-foot control tower will be constructed of reinforced concrete. As with Big Dry

Creek tower, the Little Dry Creek tower will be kept dry at all times. The tower will house two sets of tandem emergency and service gates placed side by side. Each set of gates will be capable of independent operation. Both sets of gates will be located in covered slots in the control chamber floor and will be operated from a control room located at the top of the tower. Each gate will be a 6.5 foot by 3.0 foot wedge lock slide gate. Wedge lock type gates are considered the most practical type for the required service because of their suitability for operation under a partially open condition, practicability for making fine adjustments required for flow regulation, simplicity of design and control, low potential for obstruction, low potential for damage by flow of debris through the gate opening, and comparatively low maintenance cost. The upstream gates will be the emergency gates and the downstream gates will be the service gates. Air will be supplied to the top of the conduit immediately downstream of each service slide gate, by an 8-inch diameter air-intake pipe. The air intake will be positioned above the maximum pressure head expected in the conduits, for vacuum relief. The air vents were sized in accordance with HDC 050-1 and were based on an 80 percent gate opening at gross pool elevation 433.2 and an air flow velocity of 150 fps.

(c) Conduit. - The outlet works conduit will consist of a rectangular reinforced concrete conduit 5.0 feet wide and 6.5 feet high connected to a dual intake passageway at elevation 403.0. Each intake passage will be 3.0 feet wide and 6.5 feet high. Conduit sizing was based on an intake loss coefficient of 0.19, estimated from Plate C-32 of EM 1110-2-1602, a surface wall roughness (Ks) of 0.003 feet, and an exit loss coefficient of 1.0. A 5-foot thick center pier will separate the intake passageways. Steel lining will be provided from each emergency slide gate to 5 feet downstream of each service slide gate to protect against the possibility of cavitation damage. A 24-foot section downstream of the lining will provide a transition from the dual gate section to the single 5.0-foot wide by 6.5 feet high conduit. The single conduit downstream of the dual passageway, will have a slope of 0.0129. Each gate section has been sized to pass 80 percent of the maximum 700 cfs discharge in the event that one gate is inoperable.

(d) Energy Dissipator. - The conduit will exit at invert elevation 401.0 on to a parabolic drop leading to a hydraulic jump stilling basin. The stilling basin has been designed for the maximum anticipated discharge of 700 cfs at gross pool elevation 433.2 and a tailwater to sequent depth ratio (TW/D2) of 1.0. Because the outlet works will be operated at part-gate openings for the design condition, a forewater was run using a Manning n-value of 0.012 in order to determine the flow depth and velocity at the conduit exit. The flow depth was computed to be 3.82 feet with a velocity of 36.7 fps. The tailwater elevation in the existing exit channel corresponding to 700 cfs is 399.7. The tailwater computation was based on HEC-2 backwater runs of the existing channel downstream from the outlet works. The stilling basin will have an apron elevation of 387.0, a width of 16.5 feet, and a length of 32.0 feet. The parabolic drop will be 41.93 feet in length with a flare ratio of 6.97. A radius of 25 feet will connect the side wall of the conduit to the parabolic drop flare. Two rows of baffle blocks will be provided. Baffle block height, width and spacing were set at 1.0 feet. The first row of baffles will be located 16.0 feet downstream from

the start of the basin. The second row of baffles will be set approximately 6.0 feet downstream of the first row. The end sill will be 0.5 feet high.

(e) Exit Channel. - The exit channel will be 20.0 feet wide at the end of the stilling basin. A preformed riprapped scour hole 5.0 feet below the stilling basin end sill will be provided. The exit channel will have an adverse bottom slope of 0.1 from the scour hole invert to the existing exit channel invert. The excavated channel banks shall be provided with riprap protection.

(4) Dry Creek Crossing of the Friant-Kern Canal. - The Dry Creek crossing of the Friant-Kern Canal at canal Station 820+00 and the adjacent canal embankments on the east side will be modified so that comingled SPF flows from Dry and Dog Creek can safely pass over the canal and into Big Dry Creek Reservoir. A plan of the crossing area and proposed modifications are shown on Plate B45.

(a) Canal Crossing. - The top of the crossing headwalls are currently at elevation 466.3 and 465.9 for the upstream and downstream sides, respectively. The two 65-foot long headwalls will be raised to elevation 470.0, including 3 feet of freeboard. Also, an inverted "T" shaped wing wall will be added to each headwall on the upstream side. The wing walls will extend 40 feet upstream and downstream along the Friant-Kern Canal to prevent flow from entering the canal.

(b) Friant-Kern Canal Embankment. - The Friant-Kern Canal embankment on the upstream side of the crossing will be raised from the existing crest elevation, which varies from elevation 466.0 to 467.0, to elevation 470.0. The raised embankment will extend from the siphon, northwest about 750 feet, to where it will tie into an existing knoll.

(c) Dry Creek Embankment. - The Dry Creek embankment is part of the existing Big Dry Creek project. The portion of embankment east of the Friant-Kern Canal will be raised in a manner similar to the Friant-Kern Canal embankment. The raised portion consists of two sections. The first section, with crest elevation 470.0, extends southeasterly for about 400 feet from the downstream siphon headwall. The second section, with crest elevation at 471.0, extends northeasterly for about 1,300 feet to where it ties into the existing ground.

(d) New Embankments. - In addition to raising the existing Friant-Kern Canal embankment and Dry Creek embankments, two new embankments will be constructed in the area to contain SPF flows, insuring that they will pass over the Friant-Kern Canal. They will be located northeast of the crossing and tie into the natural ground at elevation 471.0. The two embankments will have crest elevations of 471.0, a maximum height of 5 feet, 3 feet of freeboard, a crest width of 10 feet, and 1V on 2.25H side slopes. One will be 100 and the other 300 feet long.

c. Fancher Creek Dam. -

(1) Spillway. - The spillway at Fancher Creek Dam is designed to safely pass the PMF with 3.0 feet of freeboard. The spillway crest elevation

was set at 480.5, the maximum pool elevation (gross pool) experienced during the 200-year design event. The top of the dam embankment was set 3.0 feet above the PMF pool, at elevation 493.3. The maximum PMF inflow to Fancher Creek Reservoir is 20,600 cfs. The resulting maximum combined spillway and outlet works discharge and flood pool elevation will be 7,100 cfs and 490.3, respectively. The PMF routing and spillway rating curves are shown on Plates F3 and F4, respectively. During the PMF routing the ungated outlet works was assumed to be functioning. The routing was initiated at gross pool elevation 480.5.

(a) Approach Channel. - Because the spillway is through the embankment, particular care was taken to protect the embankment from high approach velocities. From the 60-foot wide crest, the approach channel width is flaired to 108 feet. On the outside of the approach wall, the embankment is protected by a 4-foot thick layer of derrick stone varying in width from 30 to 50 feet from the wall and by a 15-inch thick, 25-foot wide transition layer of riprap between the derrick stone and the embankment.

(b) Spillway Crest. - Because of the suitability of the site topography and the desire to utilize the existing 30-foot wide Friant-Kern Canal overchute, the best spillway design was found to be an ogee through the dam embankment. The spillway crest will be a high ogee shape with an approach depth/design head (P/H) ratio greater than 1.33. Previous studies investigated an underdesigned crest. However, routings for an underdesigned crest versus a standard crest indicate a difference in maximum pool elevation of less than 0.15 feet. Therefore, to avoid the costs associated with the possible need for a model study for an underdesigned crest, a standard crest was selected using discharge coefficients corresponding to a P/H ratio of 1.33. An economic analysis of spillway width versus top of dam indicated the most economical spillway width to be 60 feet. The ogee crest was designed for a head of 9.8 feet and will terminate on a slope of 1V on 0.75H. A toe curve with a 20-foot radius will connect the ogee crest to the spillway chute at invert elevation 457.8. The 60-foot wide spillway chute will converge to the 30-foot wide Friant-Kern Canal overchute over a distance of 160 feet.

(c) Stilling Basin. - The flow depth at the toe of the ogee was computed to be 2.45 feet. A forewater to the end of the overchute using a Manning's n-value of 0.015 resulted in a flow depth of 6.4 feet and a velocity of 35 fps at the start of the parabolic drop to the stilling basin. The parabolic drop was designed in accordance with EM 1110-2-1602 (Hydraulic Design of Reservoir Outlet Works). The stilling basin was designed for a tailwater/sequent depth ratio (TW/D2) of 0.9. The tailwater was computed based on normal depth for a 40-foot wide trapezoidal exit channel on a slope of 0.002. The tailwater will be reevaluated when detailed topography of the downstream channel is available. The stilling basin was designed in accordance with draft EM 1110-2-1603 (Hydraulic Design of Spillways). The new hydraulic jump stilling basin, to be constructed on the west side of the Friant-Kern Canal, will be 68 feet long (set at 3D2) and 40 feet wide with an apron elevation of 435.7. Two rows of baffle blocks will be provided. Baffle block height, width, and spacing were set at 3.5 feet, approximately the entering flow depth D1. The first row of baffles will be set at 1.5 D2, or 34 feet from the start of the stilling basin. The second row of baffles will be placed downstream at approximately 0.5 D2 or 12.0 feet from the first

row. The stilling basin wall height includes 3.0 feet of freeboard. The end sill will be 1.0 feet high. The adverse channel slope downstream of the end sill will be initiated 1.0 feet below end sill elevation.

(d) Exit Channel. - The exit channel will be riprapped and provided with a preformed scour hole. The exit channel will be 700 feet long, trapezoidal shaped, with a 40-foot bottom width, side slopes of 2V on 1H, and a bottom slope of 0.002.

(2) Outlet Works. - The outlet works will be placed through the ogee crest and have an invert elevation of 457.8. The outlet works will be a square concrete conduit, 3 feet wide by 3 feet high, fitted with a steel flow restrictor to limit the maximum discharge to 100 cfs at gross pool, elevation 480.5. The flow restrictor will be placed just downstream of the entrance roof curve, creating an opening 1.22 feet high with a lip shape the same as a conventional slide gate. Although flow is open channel downstream of the restrictor, a 6-inch diameter air vent will be provided, sized according to HDC 050-1 for the 1.22-foot opening, with an air velocity of 150 fps, and a discharge coefficient of 0.74. An eyebrow will be provided at the conduit exit to prevent damage caused by spillway flows. Elliptical side wall and roof curves will be provided at the intake with x and y dimensions of 1.0 times and 0.67 times the conduit dimension of 3.0 feet, respectively. The conduit entrance will be protected by a trashrack 6.5 feet wide and 9.0 feet high with bar spacing of 2 feet wide by 0.75 feet high, based on 2/3 of the restrictor opening. The velocity through the trashrack will be less than 3 fps.

d. Pup Creek Detention Basin. -

(1) Outlet Works. - The outlet works at Pup Creek Detention Basin was designed to discharge 25 cfs at the maximum pool elevation of 376.8, which corresponds to a storage capacity of 495 acre-feet. The outlet works will consist of a 3.0-foot diameter precast concrete conduit, chosen as the minimum size for inspection purposes. It will require a steel flow restrictor at the intake to limit the discharge to the required 25 cfs. The flow restrictor will be a flat, square-edged plate essentially acting as a slide gate in a circular conduit. For computational purposes, the discharge coefficient was estimated from curves presented in "Factors Influencing Flow in Large Conduits" (ASCE November 1965). Slotted bolt holes will be provided in order to field adjust the position of the flow restrictor should flow measurements indicate the need. Using the orifice equation, the restrictor will be placed 1.32 feet above the conduit invert elevation of 366.0. The depth at the vena contracta for the estimated discharge coefficient of 0.32 will be 0.59 feet. A trashrack will be provided at the intake to protect the orifice opening from debris. The trashrack will be 4.0 feet wide and extend to elevation 372.5 between vertical retaining walls, required because the outlet works is set back into the cut slope. The trashrack will be placed on a 2V on 3H slope with horizontal bar spacing set at approximately 2/3 of the restrictor opening, or 1.0 foot. One vertical bar will be placed midway in the 4.0-foot width. The average velocity through the trashrack will be about 1.0 fps. The outlet works rating curve is shown on Plate P2.

(2) Energy Dissipation. - A rock-lined basin will be provided for energy dissipation at the conduit exit. The basin was designed based on guidance provided in HDC 722-6. A forewater for the design discharge of 25 cfs, using a Manning n-value of 0.012, indicated that at the conduit exit the flow depth would be 0.8 feet and the velocity would be 16.5 fps. Because of the high velocity, the approach slope from the conduit exit to the basin floor will be set at 1V on 10H to allow additional length for the flow to spread. In addition, the approach slope, the basin floor, and the side slopes to the end of the basin floor will be protected by grouted riprap. The upper 1/3 of the surface rock will remain exposed to provide frictional resistance. The basin depth will be 0.5 of the conduit diameter (D) or 1.5 feet. The basin width will be 2.0 D or 6.0 feet and the basin length will be 3.0 D or 9.0 feet. Basin side slopes will be 1V on 3H up to 1.5 feet, the height of the basin proper, and 1V on 2H to the existing ground elevation. A 1V on 3H adverse slope will connect the basin floor with the downstream exit channel. Riprap will be provided on the adverse slope and for 10 feet downstream. The riprap was sized using HDC 722-7. Because flow is open channel, the equivalent conduit diameter was taken as the square root of the flow area and the minimum D-50 size was thus computed to be 4.4 inches, with an equivalent W-50 of approximately 6.0 pounds. From Inclosure 3 of ETL 1110-2-120, a riprap layer thickness of 15 inches was selected with a minimum W-50 of 10.0 pounds. The riprap will have a D_{50} size of 12 inches. The tailwater surface elevation for the design flow will be 368.0, or 2.0 feet above the exit channel invert, elevation 365.9.

(3) Exit Channel. - The exit channel will have a 10-foot bottom width with side slopes of 1V on 2H and an invert slope of 0.0003. The exit channel will extend for approximately 640 feet downstream from the outlet works headwall to North Temperance Avenue. At North Temperance Avenue the existing culvert will be replaced by one 48-inch diameter reinforced concrete pipe. The 48-inch pipe will extend to the City of Clovis' storm drain system about 2,320 feet downstream of North Temperance Avenue. The invert of the City of Clovis' storm drain pipe will match the invert of the proposed 48-inch pipe at this point. The combination drainage system is capable of handling an inflow of 40 cfs, which will be sufficient for combined detention basin discharge and local inflow from collector laterals.

e. Alluvial Drain Detention Basin. -

(1) Outlet Works. - The outlet works is designed to discharge 25 cfs at the maximum pool elevation of 386.4, corresponding to a storage capacity of 385 acre-feet. The outlet works conduit will be a circular 3-foot diameter conduit, chosen as the minimum for inspection purposes and requiring a steel flow restrictor to limit the discharge to 25 cfs. The flow restrictor will be a flat, square-edged plate essentially acting as a slide gate in a circular conduit. For computational purposes, the discharge coefficient was estimated from curves presented in "Factors Influencing Flow in Large Conduits" (ASCE HY Journal, November 1965). Slotted bolt holes will be provided in order to field adjust the position of the flow restrictor should flow measurements indicate the need. Using the orifice equation, the restrictor will be placed 1.4 feet above the conduit invert of 377.9. The depth at the vena contracta for the estimated discharge coefficient of 0.35 will be 0.64 feet. A trashrack will be provided at the intake to protect the

orifice opening from debris. The trashrack will be 4.0 feet wide and extend to elevation 382.0 between vertical retaining walls which are required as the outlet works is set back into the cut slope. The trashrack will be placed on a 1V on 1.5H slope with horizontal bar spacing along the slope set at approximately 2/3 of the restrictor opening or 1.0 feet. One vertical bar will be placed midway in the 4.0-foot width. The average velocity through the trashrack will be about 1.0 fps. The outlet works rating curve is shown on Plate A2.

(2) Energy Dissipator. - A rock-lined basin will be provided for energy dissipation at the conduit exit. The basin was designed based on guidance provided in HDC 722-6. A forewater for the design discharge of 25 cfs using a Manning n-value of 0.012 indicated that at the conduit exit the flow depth would be 1.05 feet and the velocity would be 11.2 fps. Because of the high velocity, the approach slope from the conduit exit to the basin floor will be set at 1V on 10H to allow additional length for the flow to spread. In addition, the approach slope, the basin floor, and the side slope to the end of the basin floor will be protected by grouted riprap. The upper 1/3 of the surface rock will remain exposed to provide frictional resistance. The basin depth will be 0.5 of the conduit diameter (D) or 1.5 feet. The basin width will be 2.0 D or 6.0 feet, and the basin length will be 3.0 D or 9.0 feet. Basin side slopes will be 1V on 3H to 1.5 feet, the height of the basin proper, and 1V on 2H to the existing ground elevation. A 1V on 3H adverse slope will connect the basin floor with the downstream exit channel. Riprap will be provided on the adverse slope and for 10 feet downstream. The riprap was sized using HDC 722-7. Because flow is open channel, the equivalent conduit diameter was taken as the square root of the flow and the minimum D-50 size was thus computed to be 3.4 inches with an equivalent W-50 of approximately 3.0 pounds. From Inclosure 3 of ETL 1110-2-120, a riprap layer thickness of 12 inches will be required. Because it will be more economical to have the same gradation for both Pup and Alluvial basins, a 15-inch riprap layer was selected.

(3) Exit Channel. - The exit channel will be 5 feet wide with side slopes of 1V on 2H and an invert slope of 0.0003. At Armstrong Avenue, 600 feet downstream from the outlet works, the existing culvert will be replaced by a 50-inch wide by 31-inch high precast concrete arch culvert. The culvert design was based on "Measurement of Peak Discharge at Culverts" (B.L. Bodhaine, 1982). Flow will be subcritical, open channel through the culvert. The culvert was oversized so as not to significantly increase the tailwater at the outlet works. The tailwater was computed to be 0.1 foot greater than the normal depth of 1.8 feet. The exit channel will continue downstream from Armstrong Avenue about 1,400 feet until it meets the existing channel invert.

f. Redbank Creek Detention Basin. -

(1) Control Structure. - A set of two buoyancy activated, automatic, constant downstream water surface gates set side by side in the control structure will be provided to regulate releases from Redbank Detention Basin.

For hydraulic evaluation, Avio gates, designed and manufactured by Alsthom Atlantic, Inc. were used as the basis for analysis. These gates have been used at flood detention basins by the City of Syracuse, New York. The gates have operated successfully for 5-years with no undue maintenance. During one flood, the design discharge of 300 cfs was achieved and, although rapid head fluctuations up to 12 feet and high velocities through the gate were reported, the gate operations remained stable with no undue vibration nor downstream erosion. Energy dissipation downstream of the gates is provided by a concrete-lined expansion basin designed according to the manufacturer's literature. Operation of the Redbank Creek control structure will be very similar to that experienced by the City of Syracuse.

The gates will operate simultaneously to maintain the water surface at elevation 338.5, downstream of the control structure, which corresponds to 200 cfs in the exit channel. Each gate is capable of releasing 180 cfs (90 percent of design discharge). When the tailwater is below the flotation chamber the total discharge will be less than the design release of 200 cfs and controlled by the orifice. The lower portion of the rating curve was based on free orifice discharge, the condition when the gates are fully open. When the tailwater contacts the lower flotation, chamber the gate becomes operable. As flow in Redbank Creek approaches 200 cfs, the discharge increases as the differential head between headwater and tailwater increases until the design outflow of 100 cfs per gate is achieved. Once design discharge is achieved, each gate discharges 100 cfs to maintain a constant tailwater corresponding to the total flow of 200 cfs. The upper portion of the rating curve was based on available gate manufacturer's literature. Routing of the 200-year design flood using this gate operation resulted in a 940 acre-foot detention basin and a maximum pool elevation of 349.3. Each gate will be provided with a trashrack with a clear spacing of 2/3 of the headwall orifice opening. The invert of the gate orifice would be set at elevation 333.7. This would allow discharge of minor flood waves through the headworks without loss of basin storage.

(2) Rerouted Mill Ditch. - The rerouted Mill Ditch will have a bottom width of 12 feet, side slopes of 1V on 3H, and an invert slope of 0.0013. Maximum flows would occur during the irrigation season with velocities of approximately 4 fps. Gabion-type erosion protection will be provided on the outside of channel bends.

34. Freeboard. -

a. Functional Criteria. - Freeboard allowances for the project facilities were evaluated and established following the guidelines set forth in DAEN-CWH-Y/D, 21 November 1984, 2nd Endorsement to SPKED-D, 10 August 1984, basic letter, subject: Redbank and Fancher Creeks Project, Freeboard and Riprap Considerations. The applicable portions of the following documents, cited in the referenced 2nd Endorsement, were utilized to determine acceptable freeboard allowances:

1) EM 1110-2-1101, "Design Criteria for Systems of Small Dams"

2) EM 1110-2-2300, "Earth and Rock Fill Dams, General Design and Construction Considerations"

3) EC 1110-2-27, "Policies and Procedures Pertaining to Determination of Spillway Capacities and Freeboard Allowances for Dams"

4) ETL 1110-2-305, "Design Wave Height Determination"

5) ETC 1110-2-221, "Wave Runup Determination"

6) Coastal Engineering Research Center, Shore Protection Manual-1977 Edition, Wind Setup determination.

b. Dams. - The crest elevations for Big Dry Creek and Fancher Creek Dam are based on an evaluation of the most severe hydrologic conditions anticipated coupled with a freeboard allowance which exceeds the height of the wind generated design wave runup. For both dams, a full reservoir (water surface at the spillway crest) was assumed at the onset of the spillway design flood (PMF). This reflects the worst conditions either facility could be subjected to. The wind generated design wave runup values, based on SDF pool configurations and prevailing wind data, are 2.5 feet and 1.5 feet for Big Dry and Fancher Creek reservoirs, respectively. Design wave runup data are shown on Table H-19. Since a 3-foot freeboard allowance exceeds the significant wind generated design wave runup heights for either Big Dry Creek or Fancher Creek Dam, a 3-foot freeboard allowance was selected for each facility. At least 5 feet of freeboard will actually be experienced, except for 10 to 12 hours, during passage of a PMF event. A flood greater than a 1,000-year event will be required to encroach on 5 feet of freeboard. The selected freeboard allowance will provide an acceptable safety factor against overtopping during the most severe sequence of flood events which can be projected for Big Dry and Fancher Creek reservoirs.

For evaluative purposes, an additional SDF routing (based on a PMF event) was performed for each reservoir starting with an initial reservoir level equal to 50 percent of the flood control space. The resulting maximum SDF water surface elevations were slightly lower than the routings starting at spillway crest. However, addition of 5 feet of freeboard, as prescribed by EC 1110-2-27 for a routing starting at 50 percent of the flood control space, results in dam crest elevations for Big Dry and Fancher creek reservoirs nearly 2 feet higher than the routings initiated at spillway crest with 3 feet of freeboard. A 5-foot freeboard allowance is 2 to 3 times greater than the wind generated design wave runup values computed for the respective reservoirs.

Because there is no reliable rational way of estimating the initial reservoir level that is likely to prevail at the beginning of a SDF, the selected methodology conservatively assumed the initial water surface to be at spillway crest. The addition of 3 feet of freeboard (the minimum value specified in EC 1110-2-27) to the resulting SDF water surface elevation produced a facility with a lower embankment and thus lower over all facility cost than the alternative evaluated. The selected SDF routing and freeboard procedure cited above results in a facility with a very high safety factor against overtopping at a lower cost than the alternative considered.

c. Detention Basins. - Based on a review of EC 1110-2-27 and considering the size and nature of these impoundments, a wide range of design

options were considered. The resulting designs reflect the most economical basins which are technically sound, safe, and functionally responsive to the operational requirements for the project. Each of the three basins have been designed with no freeboard allowance above the maximum design event (200 year flood in each case) water surface elevation. A specific discussion for each basin follows:

(1) Alluvial Drain Detention Basin. - This basin will be completely incised, excavated below grade. Therefore, flows in excess of the design event will overflow the basin and return to the natural channel and swales that would normally be flowing during a significant event without the potential for a catastrophic embankment breach flood wave. For any equivalent event, the total flooding for project conditions will be less than for preproject conditions.

(2) Redbank Creek and Pup Creek Detention Basins. - Optimization studies for these facilities indicate that partially incised-partially embankment contained facilities are more economical. As embankment retained storage is increased, the potential for a catastrophic type overtopping/breaching failure increases and thus a spillway with associated surcharge storage and freeboard allowance must be considered, adversely affecting total facility cost. Considering the surrounding relatively flat topography and embankment alignment, 3-foot maximum height embankment sections with no freeboard allowance have been selected to retain the design event for each facility. These embankments will be protected with a soil cement cap and downstream apron to prevent erosion and possible failure should overtopping occur. Chapter VI - Geology and Construction Materials contains a description of the protective soil cement layer. Plates P1 and R1 show embankment locations and a typical section. For each facility, the resulting project downstream floodplains for events which exceed the 200-year design event will be less than or equal to the preproject floodplain for the same event, except for a localized area immediately downstream of each facility.

35. Drawdown Rates for Reservoirs and Detention Basins. - Curves showing drawdown rates for the reservoirs and detention basins are shown on Plates B7, F4, P2, A2, and R3. The drawdown rates were computed according to the criteria of ER-1110-2-50, "Low Level Discharge Facilities for Drawdown of Impoundments". The inflow during the drawdown period is the average inflow of the highest consecutive four-month period, with each monthly period being the average historical flow for that month. Historical inflow data is only available for Big Dry Creek reservoir; therefore, this flow data was transferred to Fancher Dam and the detention basins by the ratio of the drainage area times the square of the normal annual precipitation. For Big Dry Creek and Fancher Creek reservoirs the starting elevation for the drawdown is the spillway crest elevation; for the detention basins the starting elevation was taken as the maximum pool during the 200-year project design flood. The objective of the drawdown is to achieve 10 percent of the starting storage in a period of less than 120 days. Results are shown in the following tabulation:

Drawdown To 10% Capacity	Average Inflow Highest Four Starting Pool Elevation		Elevation Consecutive Months	Time Required 10% Starting Storage
	(ft-msl)	(cfs)	(ft-msl)	(days)
Big Dry Creek 22	432.6		31.0	411.3
Fancher Creek 77	480.5		8.0	464.3
Redbank Creek 2	349.3		6.0	342.6
Pup Creek 15	376.8		1.0	367.2
Alluvial Drain 13		386.4	1.0	378.8

Since times required to drawdown the reservoirs and detention basins are less than the four months allowed in ER 1110-2-50, the conduit sizes are considered adequate.

36. Water Quality. - Construction and operation of the Redbank and Fancher Creeks, single purpose, flood control project will not change the water quality of the project area streams. However, the quality of Dry Creek and the residual pool at Big Dry Creek Dam and the general quality of other project area streams have been determined to a degree during CP&E studies.

Water samples were taken of the residual pool at Big Dry Creek Dam on 27 July 1982 and of Dry Creek upstream from the pool in April and May of 1984 and February and March of 1985. The quality of flowing Dry Creek water was found to be better than the quality of water in the residual pool. Laboratory analysis of the samples taken and field collected data from the residual pool are summarized in Table 18 and show that some water quality characteristics (nutrient and metal concentrations) exceed criteria for contact recreation and freshwater aquatic life. However, a review of criteria developed since 1976 shows that wide variations occur in the suggested criteria for metal concentrations; the criteria for cadmium and mercury have been changed by a hundred fold, for example. At the time water samples were taken, the "Residual Pool" had receded to the point where two smaller pools were in evidence.

37. Hydrologic Consideration of Diversion During Construction. -

a. Big Dry Creek Dam. - Big Dry Creek Dam is scheduled to be constructed during two construction seasons. The outlet works will be replaced during the first season and available for passing flood flows during the winter. This will permit floods up to and including the 60 year flood to be passed without damage to the outlet works structure. Prior to the second flood season the spillway replacement will be completed and the dam embankment finished.

b. Fancher Creek Dam. - Fancher Creek Dam is scheduled to be constructed during two construction seasons. Modification of the existing Friant-Kern Canal is not expected. Construction will take place from Aprilto October when flows in Hog and Fancher Creeks are minimal, usually no flow, thus requiring no diversion plan. Only portions of the embankment will be constructed during the first construction season to insure that preproject flood flow paths will remain intact between construction seasons. The embankment will be constructed to elevation 474.5, 6.8 feet above the existing height of the Friant-Kern Canal embankment at the Fancher Creek overchute during the second project construction season. The construction of the ogee section and remaining embankment will not take place until the second (last) construction season. This will permit all flows up to and including the project design flood to pass through the project site without damage to the constructed embankment. The risk of a flood equal to or greater than the project flood occuring during the construction is less than one percent.

Table 18

Summary of Big Dry Creek Dam and Residual Pool Water Quality

	Units	Data Collected: Northern Pool	Data Collected: Southern Pool	Water Quality Criteria
Field Collected Data				
General Color		Deep Green	Deep Brown	None
Light Penetration	(inches)	2 in.	1/2 in.	48 1/
pH		8.5	8.5	6.5-8.5 2/
Visible Depth			1/2 in.	4 feet 1/
Phytoplankton Analysis				
Biomass on the surface	mg/L	272	104	< 1.5
Dominate genus		Anacystis	Anacystis	None
Laboratory Chemical Analysis				
Turbidity	(NTU)	50	290	
Nitrogen Concentration (KJEL.N)	mg/L	7.6	17.0	0.03mg/L 3/
Total Phosphorus	mg/L	0.69	1.8	0.05mg/L 3/
COD	mg/L	104	358	None
TSS	mg/L	89	537	100 1/
Cadmium	ug/L 4/	6	4	0.045 2/
Copper	ug/L	19	40	5.6 2/
Lead	ug/L	4.6	22	14.4 2/
Zinc	ug/L	10	54	47 2/

1/ Contact Recreation Criteria
2/ EPA Fresh Water Aquatic Life Criteria
3/ Threshold Concentrations for Supporting Visible Phytoplankton Blooms (Sawyer, 1945)
4/ ug/L is equivalent to micrograms per liter

c. Pup Creek and Alluvial Drain Detention Basins. - These basins are scheduled to be completed in one construction season. Because of this schedule and because they will be located on intermittant streams, no stream diversion will be required. Diversion of the Enterprise Canal may be required for the construction of the Alluvial Drain outlet works. This diversion is described in Chapter XI - Construction Sequencing and Diversion Plan.

d. Redbank Creek Detention Basin. - Redbank Creek Detention Basin is scheduled to be built in two construction seasons. Construction of the basin and control structure will require diverting Mill Ditch and Redbank Creek around the control structure construction site. During the first construction season, flows in Mill Ditch will be rerouted around the basin site by constructing a new portion of Mill Ditch to the south of the detention basin. The new portion of Mill Ditch will be connected to the existing Mill Ditch downstream of the control structure site. This rerouting of flows provides only part of the required diversion. Redbank Creek flow will be diverted around the control structure site by a temporary diversion ditch. Coffer dams in Redbank Creek will isolate the construction site and force creek flow into the diversion ditch, upstream, and into Mill Ditch, downstream of the control structure site. This is shown on Plate R12. The diversion ditch will have 500 cfs capacity, sized to convey most of the reservoir design flood inflow of 570 cfs.

38. Regional Geology. -

a. Geomorphology. - Most of the project lies within the Great Valley geomorphic province in an area where alluvial plains or fans are the dominant features. Portions of Big Dry Creek Dam and the Fancher Creek Dam sites lie within the Sierra Nevada province where foothills and mountains dominate. Erosion of the Sierra Nevada Range has produced a series of coalescing alluvial fans along the eastern margin of the San Joaquin Valley. The area east of Fresno is made up of a medial compound alluvial fan bordered on the northwest and southeast by the San Joaquin River and Kings River high alluvial fans. The high fans are described as ones which lie above, and are no longer being inundated by, the present channel. The proposed features are located within the boundaries of this medial fan. The fan is 26 miles long, ranges in elevation from 250 to 650 feet, and has an average surface slope of less than 16 feet per mile. It is formed by deposits derived from intermittent streams including Dry, Fancher, Pup, and Dog Creeks, and Redbank Slough. Narrowing basinward from a wide multiple-entry apex, the compound fan shape is confined and controlled by the adjacent high alluvial fans.

b. Geologic Structure. - The subsurface materials in the area consist of Pre-Tertiary basement rocks, Cretaceous and Tertiary consolidated continental rocks, Tertiary and Quaternary unconsolidated continental deposits, and Quaternary alluvial material.

(1) Basement Complex. - The basement complex consists of pre-Cretaceous metasedimentary and metavolcanic rocks and Jurassic-Cretaceous igneous rocks. The metamorphic rocks were formed when granitic plutons of the Sierra Nevada batholith intruded and altered pre-existing marine sedimentary and volcanic deposits. Subsequent uplift and erosion has stripped away most of the older metamorphic material, leaving only remnants of the original rock as pendants on the younger igneous plutons. Along the eastern portion of the Valley where the basement complex dips gently toward the west, the depth to the basement material is shallow. Farther west, the basement rock dips more steeply and the depths become progressively greater, reaching approximately 30,000 feet at the axis of the Valley.

(2) Consolidated Continental Rocks. - The consolidated continental rocks, consisting mainly of sandstone, siltstone, and shale, lie uncomformably on the basement complex at depths of approximately 1,000 feet. The only outcrop of rock of this age is a narrow exposure of the Eocene Age Ione Formation along the western front of the foothills north of the San Joaquin River.

(3) Unconsolidated Continental Rocks. - Directly overlying the consolidated rocks are Tertiary to Quaternary Age unconsolidated deposits of the Kern River, Zilch, and Walker Formations. These formations primarily contain interbedded lenses of arkosic clay, silt, sand, and gravel derived from the crystalline bedrock of the Sierra Nevada plutons. These deposits lie at depths ranging from 250 to 450 feet in the Fresno area and do not crop out in the area.

(4) Alluvial Material. - Quaternary alluvial deposits comprise the major surface and subsurface units in the Fresno area. These deposits consist of terrace, flood plain, river channel, and alluvial fan deposits. From oldest to youngest the alluvium includes the Turlock Lake, Riverbank, and Modesto Formations of Pleistocene and Holocene age. These materials were deposited by small intermittent streams, and contain lenses of sand, gravel, and cobbles intercalated with silt and clay. Uncomformably overlying the older alluvium is a thin deposit of Recent Aged fluvial, arkosic beds that lithologically are very similar to that of the underlying older material.

(a) Turlock Lake Formation. - The Turlock Lake Formation is found in the San Joaquin River bluffs north of the project and as isolated outcrops east of Fresno. The formation is homogeneous and thinly bedded with both gradational, and abrupt bedding planes. These deposits seem to be related to the early Pliocene uplift of the Sierra Nevada and to the advances and retreats of the Pleistocene glaciations. The Turlock Lake Formation is generally considered to be at least 500,000 years old, based on radiometric and paleomagnetic dating techniques.

(b) Riverbank Formation. - The Riverbank Formation forms 15 to 30 feet of surficial material on the proximal reaches of the compound alluvial fan and the high fans of the San Joaquin and Kings Rivers. It is homogeneous, massively bedded, and contains an extensive iron-silica hardpan in its upper portion. The formation unconformably underlies the Modesto Formation and overlies the Turlock Lake Formation. The age of the formation is considered to be 100,000 to 300,000 years old.

(c) Modesto Formation. - The Modesto Formation comprises the youngest unit of the Fresno fans and covers a large part of the central San Joaquin Valley. In the Fresno area, the unit contains from 10 to 30 feet of poorly sorted, massively bedded material. The material displays a wide variety of mineralogies which are primarily granitic and metamorphic in origin. The Modesto Formation has undergone little erosional change. Present topographic features are due more to depositional than erosional processes. The Modesto Formation is considered to be 25,000 to 60,000 years old.

c. Faulting. - The dominant structural feature of the basement complex is the westward-tilted fault block of the Sierra Nevada associated with numerous faults collectively known as the Foothills fault system. Included in this system are the Melones and Bear Mountains fault zones, and numerous smaller unnamed faults and shear zones. Major known faults of the Foothills fault system are located approximately 45 miles northwest of the project. Although no major fault systems have been identified in the foothills east of the project, rocks of the nearby Kings River ophiolite are lithologically similar to ophiolite rocks associated with the Kings-Kaweah suture to the southeast and the Melones and Bear Mountains fault zones to the northwest. The Kings-Kaweah suture is thought to be an ancient tectonic plate margin, joining what was once late Paleozoic and Mesozoic oceanic lithosphere with older continental lithosphere. The suture zone may continue northwestward into the Western Sierra Nevada Foothills Metamorphic Belt as the Melones and Bear Mountains fault zones. If this is the case, this component of the

Foothills fault system would lie within 15 miles (24 km) of the project. Portions of the Melones and Bear Mountains faults are considered to be capable faults although they are not known to be recently active in the project area.

Other major faults that may affect the project area include the San Andreas or the Owens Valley fault, in the Sierra Nevada Frontal fault system. These faults are considered active and have had recent seismic events associated with them. The Owens Valley and Sierra Nevada Frontal systems faults are located 70 to 80 miles (113 to 129 km) east of the project along the eastern front of the Sierra Nevada Range. The San Andreas fault is approximately 80 miles (129 km) southwest of the project in the Coast Ranges.

The dominant structural feature of the subsurface sedimentary deposits is the westward dipping monocline which extends from the foothills westward to the axis of the San Joaquin Valley. The steeply-dipping folds have been restricted to the consolidated sedimentary rocks. The overlying and largely undisturbed unconsolidated deposits form a nearly flat, homoclinal sequence.

Prominent surface linear features have been observed on aerial photographs and topographic maps along the eastern portion of the valley. The lineations strike approximately N.42°W. and are expressed as a series of surface gullies and swales. Extensive geologic studies to investigate these lineations were conducted by Fugro, Inc. for the Pacific Gas and Electric Company's Central San Joaquin Valley Nuclear Power Plant Siting Study (1973, 1974). In their report, Fugro suggests that the lineations in the alluvium parallel the major lineations in bedrock and are probably expressions of the bedrock joint system that has propagated through the younger sediments. The surface lineations appear in deposits of the Turlock Lake and Riverbank Formations, but are absent in the younger Modesto Formation. Fugro states in the conclusions of their report that, "Linear features, identified from the study of remote sensing imagery and topographic maps, were examined on the ground and in the subsurface. No evidence was found to suggest their association with faulting."

A concealed fault ("Clovis fault" Plate G6) as shown on the Fault Map of California was inferred by Page and LeBlanc (1969). The existence of the fault was based on a 120-foot difference in depth to bedrock in two water wells located less than 0.5 miles apart. The Fugro explorations included drill holes in alluvial deposits of the Turlock Lake Formation on opposite sides of the Page and LeBlanc feature, and an exploratory trench across the feature. They reported, "No evidence was found of any fault-related features. The lack of structural deformation, offset beds, and seepage zones shows that these lineations are not fault-controlled, and they concluded that, "The Page and LeBlanc feature is considered to be a member of the northwest-trending set of lineations".

A lineament and photo interpretation study is being conducted for the Sacramento District by Robert Frost of the U.S. Army Engineer Topographic Laboratory. Preliminary studies have failed to show evidence of lineations in what appears to be Holocene Aged alluvium in the area east of Fresno (Frost, personal communication 20 November 1985).

d. Seismicity. - The Redbank and Fancher Creeks project is located within Seismic Zone 3. ER 1110-2-1806 (16 May 1983) indicates damage capability within this zone is considered to be major, Figure 1.

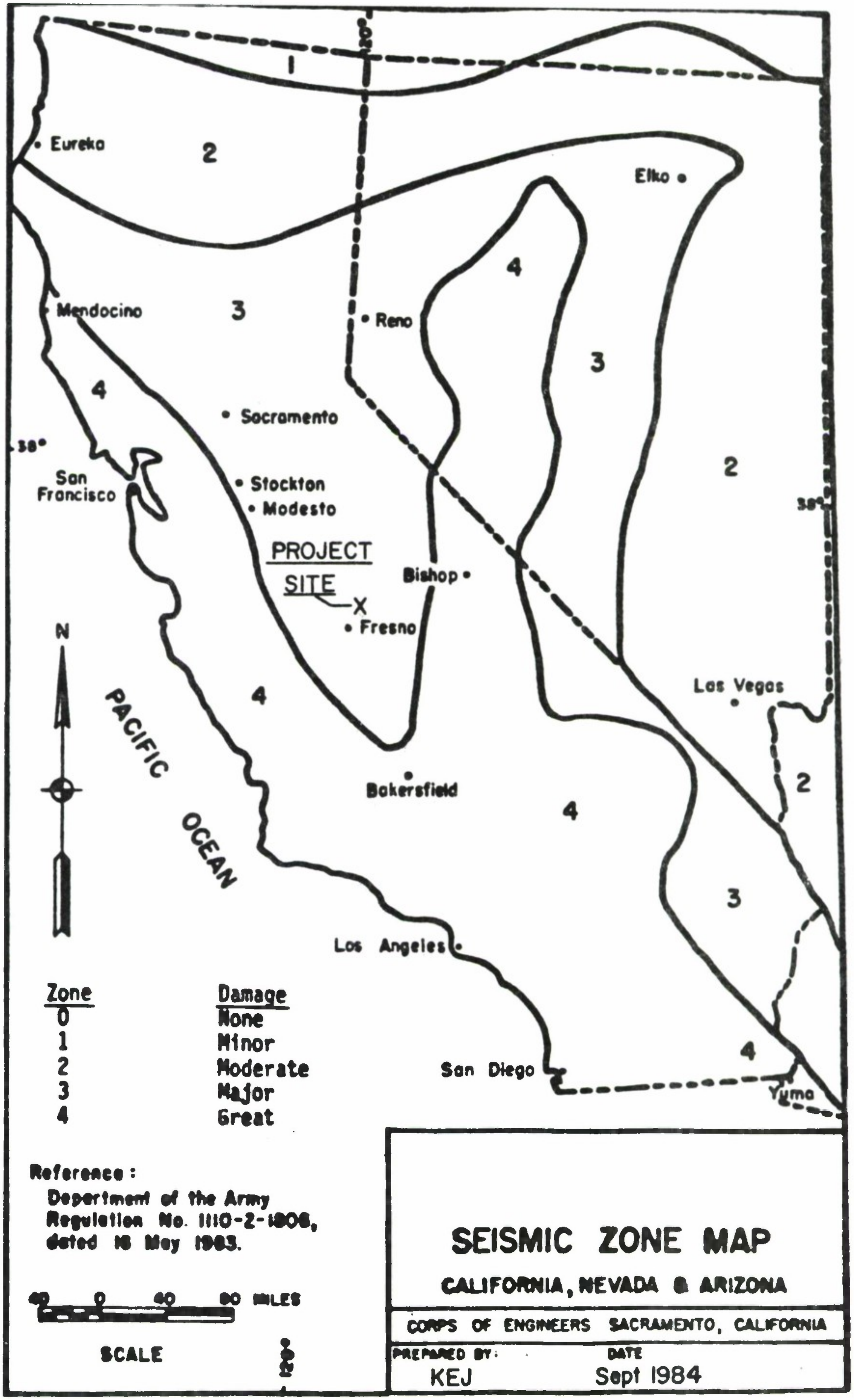
The project is approximately 60 miles (97 km) southwest of the Mammoth Lakes, California area where, five seismic events of Richter magnitudes 6.0 to 6.9, 16 events with magnitudes of 5.0 to 5.9, and numerous events with magnitudes 4.0 to 4.9 have occurred since 1900. Most recently, between 25 and 27 May 1980, three earthquakes occurred with magnitudes of 6.0 to 6.3. An earthquake of magnitude 6.7 occurred on 2 May 1983, approximately 60 miles southwest of the project near the town of Coalinga. The earthquake, which is the strongest historic event to have occurred on the west side of the Great Valley, was located on a previously unknown fault 25 miles (40 km) east of the San Andreas fault. The closest large seismic event was a Modified Mercalli Intensity VIII earthquake recorded on 30 September 1889 near Wawona, California, approximately 50 miles (80 km) north of the project. A Modified Mercalli Intensity VIII earthquake is described as being destructive with some damage to buildings.

The area within a 50-mile (80 km) radius of the project has a history of shallow (less than 25 km below the ground surface) and small (less than Richter magnitude 4.0) earthquakes. The majority of these are less than magnitude 2.0. During the months of December 1977 and January 1978 an earthquake swarm of over 100 events between magnitude 0.5 and 3.2 was recorded 9 miles south of Madera, California. This swarm, named the Madera Swarm, is located approximately 25 miles (40 km) west of the project. Observations of seismic activity in this zone to date are consistent with the historical data showing this local area to be the most active zone in the northern San Joaquin Valley (Woodward-Clyde, 1978).

A review of seismic history in the central California region indicates the fault systems which exhibit the highest probability of being the source of seismic ground motion in the Fresno area are the Owens Valley and San Andreas faults, the Foothills fault system, and faults associated with the Mammoth Lakes earthquakes.

Seismic design parameters for the project area were determined using attenuation curves presented by Seed and Idriss (1983) and Bolt (1973). Those studies indicate that an earthquake of Richter magnitude 8.25 originating on the Owens Valley fault 70 miles (113 km) east of Fancher Creek dam site, and approximately 75 miles (121 km) east of the Big Dry Dam and the detention basin sites, would set the upper limits of ground shaking intensity at the project. If the magnitude 8.25 event was centered on that portion of the Owens Valley fault the result would be a peak bedrock acceleration of 0.07g and a bracketed duration of approximately five seconds at Fancher Creek dam, and a peak bedrock acceleration of 0.06g and a bracketed duration of approximately three seconds at Big Dry Dam and the detention basins.

The southernmost portion of the Foothills fault system, as presently depicted on the Fault Map of California, lies approximately 45 miles (72 km) northwest of the project. Woodward-Clyde (1978) reports the Foothills fault system is capable of generating magnitude 6.0 to 6.5 earthquakes in the area



1
2
Eureka
Elko
4
3
Mendocino
Reno
3
4
Sacramento
38°
San Francisco
Stockton
Modesto
2
38°
PROJECT SITE
X
Bishop
Fresno
N
PACIFIC OCEAN
4
Las Vegas
2
Bakersfield
4
3
Los Angeles
4
San Diego
Yuma
Zone
0
1
2
3
4
Damage
None
Minor
Moderate
Major
Great
Reference:
Department of the Army
Regulation No. 1110-2-1806,
dated 16 May 1983.
40 0 40 80 MILES
SCALE
120°
SEISMIC ZONE MAP
CALIFORNIA, NEVADA & ARIZONA
CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA
PREPARED BY:
KEJ
DATE
Sept 1984

FIGURE 1

near New Melones Dam. Bolt (1978) suggested the upper bound for ground motion for the Merced Streams project is magnitude 6.0, due to attenuation by damping and geometrical spreading. Assuming a magnitude 6.0 earthquake occurred at the southernmost end of the Foothills fault system, attenuation curves correlating distance from causative fault and maximum acceleration (Seed and Idriss, 1983) shows that a maximum peak bedrock acceleration of approximately 0.05g could be expected at the project. Therefore, the Owens Valley fault system was the basis for project design, as described above. The joint probability of concurrent earthquake and flood events for Big Dry Creek and Fancher Creek Dam is not shown here because the small accelerations produce negligible probabilities.

e. Ground Water. - Recharge to the ground water basin is derived from irrigation, canal seepage, streamflow, rainfall, and underflow of the streams entering the area. Recorded ground-water levels indicate localized long-term trends. From January 1963 to January 1975, water levels throughout a large part of the area had a net rise of approximately 10 feet. Some of the general rise is attributed to easing of the demand on ground water because of the delivery of water to the International Water District in 1958, and to the Garfield Water District beginning in 1962 (Page, 1975). From January 1975 to January 1983, the area showed a general lowering in water levels. Although the water levels decreased as much as 20 feet in some localized areas, the water levels were still higher than those measured in 1963. This decrease may be attributed to increased population and to populated areas becoming centrally located around the urban centers, resulting in ground water being used for more than irrigation. Short-term trends show that, in general, water levels rise during winter when demand for water is at a minimum and recharge due to rainfall is greatest. It levels off during spring and declines during summer and autumn when demand is at a maximum. The proposed project should have no noticeable impact on this general trend.

39. Big Dry Creek Dam and Reservoir. -

a. Geologic and Soils Investigations. - The Big Dry Creek Dam foundation and borrow area has been investigated in 1938, 1943, 1982, 1983, and 1984. Initial explorations in 1938 and 1943 included six churn drill holes, Plates B10 and B11, 15 test pits, Plate B12, 28 auger holes, Plates B13, B14, and B15, and 48 seismic refraction lines. The locations of these explorations are shown on Plate B9. In 1982, additional investigations included eight foundation trenches, four auger drill holes with Standard Penetrometer Tests (SPT's), 10 borrow trenches, 6 undisturbed sample holes, and 7 NX diamond core drill holes. Because of high water levels in Dry Creek at the time of the explorations, two proposed foundation trenches that were to be located where the new alignment will cross the creek were eliminated. During the November 1982 exploration program, seepage was noted at an old streambed at the downstream toe between Station 188+70 and Station 191+40. The 1983 program was designed to include drilling through the embankment and into the stream channel, as well as three backhoe borrow trenches in the reservoir area. Two undisturbed sample holes were drilled along that portion of the dam, but no evidence of streambed deposits was encountered. At the time of the August 1983 drilling, seepage was still occurring but at a much smaller rate as compared to November 1982. In 1984, an additional attempt

was made to determine the extent and properties of the seepage material. The investigation included seven backhoe trenches and three auger and SPT holes with undisturbed samples. The trenches were dug first along the downstream toe of the dam to determine the type of material underlying the seepage area. Five trenches were then dug along the upstream toe to determine the lateral extent of the stream bed material. Lastly, the auger and SPT holes were drilled to obtain an undisturbed sample of the seepage material for lab testing. Three additional borrow trenches were dug in the reservoir area to help determine the quantities of borrow materials. The location of these more recent explorations are shown on Plate B16.

b. Geologic Conditions. - The area of the Big Dry Creek Dam is underlain predominantly by foliated quartz-mica schist, alluvium, and residual soil. The schist, which represents the oldest rock in the reservoir area, is exposed on low rounded hills at, and adjacent to, the right abutment and spillway. Although the schist generally is weathered to a considerable depth, the material is relatively dense and impervious with scattered lenses of hard quartzite. Some exposures of granitic material occur in the reservoir area, but they are limited to weathered outcrops at the extreme eastern edge of the site. Along the western and southwestern margins of the reservoir, the surficial materials vary in thickness from a few inches to many feet. Westward from the reservoir, the bedrock surface is covered by deep deposits of alluvium and residual soil. Recent alluvium has been deposited along the courses of Dog Creek and Big Dry Creek. These deposits are less consolidated and more pervious than older alluvial deposits. Explorations and geologic mapping in 1943 indicated that the recent alluvium was about 25 feet thick and 250 to 400 feet wide where the original Dry Creek traverses the dam. Explorations in November 1982 were conducted to determine if the stream channel material was removed during excavation. The 1982 explorations indicate the stream channel was not as extensive as anticipated, but loose sand is still present in the upstream and downstream toes of the dam, (see logs of explorations, holes 2F-1 through 2F-4). Based on laboratory tests and gradation data, this sand has a coefficient of permeability on the order of 5 to 30 feet per day. Although clean sand was not encountered in hole 7F-4, drilled through the dam and into the stream channel, the drill log shows up to 6 feet of very loose to loose silt, sand, and gravel. A downstream toe drain was incorporated into the existing dam embankment at Big Dry Creek to control seepage.

(1) Spillway Conditions. - The existing spillway is founded on slightly to highly weathered mica-schist containing a few scattered lenses of hard quartzite. Drill hole 1F-4, near the left abutment, encountered a 20.5-foot-thick zone of sandy clay between the overlying highly weathered mica-schist and the underlying slightly weathered mica-schist. This zone wasn't encountered in hole 1F-5 along the right side of the spillway. Initial exploration holes drilled in the 1940s were not deep enough to have encountered this zone. Logs of these cored drill holes are shown on Plate B19.

(2) Outlet Works. - This project includes three outlet works structures; two of which, Big Dry and Little Dry, will replace existing outlet works as a result of the project. They are located on Dry Creek,

Little Dry Creek Diversion channel, and Dog Creek. At the Big Dry Creek outlet works, schist bedrock is overlain by approximately 13 to 18 feet of clayey sand and silt. The drill log of hole 1F-6, located on the upstream side of the structure, shows highly weathered schist from 15 feet to the bottom of the hole at 25.3 feet. Hole 1F-7, drilled on the downstream toe of the dam, encountered highly weathered schist from 13.5 feet to 17.5 feet, and moderately weathered schist from 17.5 feet to the bottom at 25.0 feet. The Little Dry Creek structure is underlain by weathered mica schist at approximately 2 to 10 feet. Hole 1F-2, drilled at the upstream side of the outlet works in 1982, encountered decomposed schist at 10.0 feet, and highly weathered and decomposed schist from 19.2 feet to the bottom of the hole at 24.8 feet. Hole 1F-1, drilled at the downstream toe, encountered slightly weathered schist from 2.1 feet to the bottom of the hole at 25.0 feet. Logs of these cored drill holes are shown on Plate B19. The Dog Creek site contains materials varying from clayey sand to coarse gravelly sand, and lies adjacent to a body of weathered granitic rock which outcrops on the southeast side of the creek. No modifications are proposed to be made at the existing Dog Creek outlet works.

c. Foundation Conditions. -

(1) Soil Types. - Soils encountered during exploration of Big Dry Creek Dam foundation were generally clayey sands (SC), with lesser amounts of silty sands (SM), sandy clays (CL), sandy silts (ML) and relatively clean sands (SP-SW), Plate B17. The average gradation of 148 foundation samples analyzed for grain-size distribution contained 65% sand, 30% fines and 5% gravel. Fines ranged from non-to medium plasticity. Distribution of materials was basically random except for an approximately 500-foot wide section of clean sand located where the dam traverses Big Dry Creek. These sands, which were classified as recent alluvium, contained little or no fine sand and were generally well graded. The depth of this deposit extends to elevation 377.0 as shown on Plate B18. In order to alleviate potential seepage problems, removal of this recent alluvium will be required (see paragraph 40h(2)).

(2) Penetration Resistance. - SPT results were evaluated for two basic material types. Included were both old and recent alluvial deposits. Forming the bulk of the foundation, old alluvium was found to be generally firm with sand densities ranging to very dense, and clay consistencies extending to hard. Densities of recent alluvium varied. Field descriptions classified this material as very loose to loose, while SPT results indicate the material ranges from loose to dense (N=10 to 47).

d. Existing Embankment. - Materials sampled during explorations of the existing Big Dry Creek Dam embankment consisted of clayey sand (SC) and silty sand (SM), Plate B17. The average gradation of 51 samples analyzed for grain size distribution contained 60% sand, and 40% fines. Plasticities were generally low (LL<30), with two samples classified as non-plastic. Materials were basically non-cemented, and contained notable quantities of mica flakes.

e. Borrow Area Conditions. - The proposed borrow area for Big Dry Creek Dam is shown on Plate B42. The borrow area consists of similar materials to those already discussed under foundation conditions. Older alluvium, which comprises a majority of the available material, consists mainly of clayey sand (SC), with lesser amounts of silty sand (SM), sandy silt (ML), and sandy clay (CL), Plates B25 and B26. An average of 26 samples produced a composite containing 65% sand, 34% fines, and 1% gravel. Plasticities ranged from non-to medium. Recent alluvium, confined to Big Dry Creek streambed, contains an average of 90% sands, and 10% gravel.

f. Ground Water. - Ground water was encountered in the Big Dry Creek reservoir area. There seems to be two sources. The first is Dry Creek. Though dry on the surface, subsurface seepage flows were measured in the clean sands deposited in the creek bed. The approximate depth of water in the vicinity of Big Dry Creek Dam's traverse of Dry Creek was elevation 390. The second source of ground water appears to be the residual pool behind Big Dry Creek Dam. This conclusion is based on the similarities between the 400-foot pool elevation and adjacent ground-water levels, and the fact that no ground water was found within 10-feet of the surface in any of the borrow explorations located at elevation 410 or higher.

g. Laboratory Test Results. -

(1) Laboratory Testing Program. - Extensive primary and secondary laboratory testing was performed on foundation, existing embankment, and borrow materials. Testing included grain-size analysis, Atterberg limits, specific gravity, unconfined compression, compaction, permeability, triaxial compression, direct shear, water content, and consolidation. Testing methods conformed to procedures described in EM 1110-2-1906 (Laboratory Soils Testing, 30 November 1979). Soil samples were classified in accordance with "The Unified Soil Classification System," TM No. 3-357, Appendix A (April 1960, reprinted May 1967).

(2) Summary of Laboratory Test Results. - A summary of primary test results for Big Dry Creek Dam is shown in Table 19. The range of results, as well as averages are shown. Table 20 indicates the range of secondary test results and selected design values.

(3) Selected Design Values. - Based on laboratory test results, the following design values were selected for Big Dry Creek Dam embankment, foundation, random fill and filter and drainage material. The allowable bearing capacities of the soil were calculated from EM 1110-2-1903 (Bearing Capacity of Soils) and compared to the required bearing capacities for the design of the concrete structures in accordance with EM 1110-2-2502 (Retaining Walls) to insure foundation adequacy.

(a) Existing Embankment. -

Parameter	Design Value	
Dry Unit Weight	120	PCF
Moist Unit Weight	133	PCF

Table 19

Big Dry Creek Dam
Summary of Primary Laboratory Test Results

Material	Predominant Soil Class.	Avg. Soil Fraction % Gravel	Sand	Fines	Atterberg Limits Liquid Limits	Plas. Index	Moisture Content %	Field Density (PCF)	Gs
Foundation (Older Alluvium)	SC	0-12 5	48-83 65	5-62 31	14-60 30	2-36 10	1-31 13.8	132.0	2.76
Existing Embankment	SC	0-4 0	55-63 60	33-45 40	12-32 23	1-12 7	6-20 11	133.4	2.75
Filter Material (Recent Alluvium)	SW	3-18 10	82-94 89	0-1 1	---	NP	4	---	2.73
Random Fill (Older Alluvium)	SC	0-3 1	40-82 65	15-60 34	15-47 26	1-29 10	3-33 12	---	2.75

Table 20

Big Dry Creek Dam
Summary of Secondary Laboratory Test Results

Material	Compaction 95% (PCF)	Compaction Opt W (%)	Direct (S) Ø	Direct (S) c(PSF)	Triaxial (R) Ø	Triaxial (R) c(PSF)	Triaxial (Q) Ø	Triaxial (Q) c(PSF)	Standard Permeability (Ft/Day)	Coeff. of Kv (Avg.)	Gs	Remarks
Foundation (Older Alluvium)	--	37°	0	7°	4,400	14°	1,400		.0015-.055	0.1	2.75	Undisturbed
Existing Embankment	--	31-37° 33°	0 0	20°	1,600	35°	500		.00055-.30	0.1	2.74	Undisturbed
Filter Material (Recent Alluvium)	118.6/11.0	34°	0	34°	0	34°	0	1000			2.73	Assumed Strengths
Random Fill (Older Alluvium Alluvium)	118.5/10.5	33-37.5° 33°	0 0	18-19° 18°	600 600	20-30° 20°		800 800	.0012-10	0.1	2.75	Remolded

Direct Triaxial Triaxial

Existing Embankment (Cont'd)

Parameter	Design Value		
Saturated Unit Weight	139	PCF	
Submerged Unit Weight	76.6	PCF	
Unconsolidated-Undrained "Q" Strength	C = 500	PSF	Ø = 35°
Consolidated-Undrained "R" Strength	C = 1,600	PSF	Ø = 20°
Consolidated-Drained "S" Strength	C = 0		Ø = 33°
Coefficient of Permeability, $\bar{k}$	0.2	FPD	
Specific Gravity	2.75		

(b) Embankment Foundation.

Parameter	Design Value		
Dry Unit Weight	116	PCF	
Moist Unit Weight	132	PCF	
Saturated Unit Weight	135	PCF	
Submerged Unit Weight	72.6	PCF	
Unconsolidated-Undrained "Q" Strength	C = 1,400	PSF	Ø = 14°
Consolidated-Undrained "R" Strength	C = 4,400	PSF	Ø = 7°
Consolidated-Drained "S" Strength	C = 0		Ø = 37°
Coefficient of Permeability, $\bar{k}$	0.2	FPD	
Specific Gravity	2.76		

(c) Random Fill. - Selected design values are minimums over the range tested typical borrow material remolded to 95% standard density at moisture contents ranging from -2% to + 2% of optimum.

Parameter	Design Value		
Dry Unit Weight	115	PCF	
Moist Unit Weight	129	PCF	
Saturated Unit Weight	136	PCF	
Submerged Unit Weight	73.6	PCF	
Unconsolidated-Undrained "Q" Strength	C = 800	PSF	Ø = 20°
Consolidated-Undrained "R" Strength	C = 600	PSF	Ø = 18°
Consolidated-Drained "S" Strength	C = 0		Ø = 33°
Coefficient of Permeability, $\bar{k}$	0.2	FPD	
Specific Gravity	2.75		

(d) Filter Material and Drainage Fill. - These minimum values were based on known properties of sand and gravel. Drainage fill will be from a commercial source.

Parameter	Design Value		
Dry Unit Weight	115	PCF	
Moist Unit Weight	125	PCF	
Saturated Unit Weight	130	PCF	
Submerged Unit Weight	67.6	PCF	
Unconsolidated-Undrainged "Q" Strength	C = 0		Ø = 34°
Consolidated-Undrained "R" Strength	C = 0		Ø = 34°
Consolidated-Drained "S" Strength	C = 0		Ø = 34°
Coefficient of Permeability, $\bar{k}$	1,000	FPD	
Specific Gravity	2.65		

h. Design Analysis. - A description of the proposed typical embankment sections, seepage control features, slope protection, and excavation and fill quantities is in Chapter IV - Description of the Selected Plan.

(1) Slope Stability. - A stability analysis was performed on the proposed embankment using the circular arc method as described in EM 1110-2-1902 (Stability of Earth and Rockfill Dams, dated 1 April 1970). The analysis was performed on the Harris computer system using Program No. 741X6L2040, developed by the St. Paul District, Corps of Engineers. The circular arcs with the critical Factor of Safety were then checked manually using the Modified Swedish Method, Finite Slice Procedure. Stability analyses performed for end of construction, steady seepage, and partial pool conditions are shown on Plates B37 thru B39. A pseudostatic seismic loading condition, using a seismic coefficient of 0.1 (Seismic Zone 3), was used to evaluate seismic stability. Table 21 shows the minimum required and computed factors of safety.

Table 21

Big Dry Creek Dam, Factors of Safety

Design Condition	w/o Seismic Loading		With Seismic Loading	
	Minimum Required	Computed	Minimum Required	Computed
End of Construction	1.3	2.1	1.0	1.6
Partial Pool	1.5	1.8	1.0	1.2
Steady Seepage	1.5	1.5	1.0	1.1

The sudden drawdown condition was not analyzed by the Modified Swedish Method, Finite Slice Procedure, since the upstream shell of the dam is not anticipated to become saturated under transient pool conditions. An Infinite Slope analysis was performed assuming surficial saturated conditions. This analysis indicates a factor of safety of 1.1. This value is less than the 1.2 minimum required by Corps criteria. However, this value was determined to be acceptable since the existing dam, with water-side slopes of 1V on 2.5H, has performed satisfactorily with no evidence of sloughing under transient pool conditions for approximately 37 years. Additionally, this analysis assumed no cohesion. However, compacted soils exhibit apparent cohesion under low stresses such as those likely to develop during surficial slumping.

The phreatic surface for the Steady Seepage Slope Stability analysis shown on Plate B46 assumed existence of a permanent recreation pool. Though such a pool is no longer part of the project, such an analysis is conservative since only submerged unit weights are available to stabilize deep seated failures. The limiting condition having the lowest factor of safety was for the infinite slope case. Such a failure would be surficial in nature and would not change if a lower phreatic surface was choosen. Revised slope stability analyses, investigating use of detention basin soils and utilizing more realistic phreatic surfaces will be presented in the FDM.

Big Dry Creek Dam foundation materials were assumed to be homogeneous for slope stability analyses. Design strengths were based on average material

properties though both weaker and stronger foundation materials exist. However, since distribution of the different strength materials appears to be random at the surface and stronger with depth, such a decision was viewed as proper. Additionally, since design strengths were established such that at least two thirds of the test values were equal to or greater than the selected strengths, and safety factors against slope instability are provided, the proposed section is adequate. To further demonstrate that the proposed section is stable under worst case foundation conditions, a sensitivity study will be conducted and presented in the FDM to evaluate the effects of reduced foundation strengths on slope stability. Selected design strengths for fine grained materials will be verified by additional lab work.

(2) Seepage. - A flow net analysis, conducted on a typical section of Big Dry Creek Dam, is shown on Plate B40. Assuming steady seepage conditions develop due to long term storage at or about gross pool, total seepage through the dam and foundation is estimated at 0.64 cfs. This small amount of seepage will be effectively controlled by the horizontal and inclined drainage blankets, as well as the upstream inspection trench. Excavation of recent alluvium located at Big Dry Creek's traverse of the existing dam will preclude seepage problems in this area. Deposits of this material extend laterally from Station 132+00 to Station 137+00 and range vertically from elevation 377.0 to elevation 405.0 as shown on Plate B18.

(3) Settlement. - A settlement analysis was performed using Terzaghi's consolidation theory. At maximum section, a total settlement of 3-inches was estimated, with 70 percent occurring during construction. Of this total, it is anticipated that the foundation will settle about 3/4 of an inch, the existing dam about 1-3/4 inches and the new embankment about 1/2 of an inch. Camber in the embankment crest will not be required since less than 1 inch of post-construction settlement is estimated.

(4) Foundation Liquefaction. - A liquefaction analysis was conducted on recent alluvial deposits located beneath Big Dry Creek Dam's traverse of Dry Creek. The analysis was performed using the method described in "Evaluation of Liquefaction Potential Using Field Performance Data," (H. Bolton Seed, March 1983). This analysis utilizes the relationship between SPT results and maximum anticipated ground accelerations to predict liquefaction potential. For ground water located 5 feet below the ground surface, and probable maximum accelerations of 0.06g, the analysis indicates that liquefaction is not probable. Due to the low design accelerations, liquefaction of the older alluviums is also not likely.

i. Proposed Geologic and Soils Investigations. - Explorations to be conducted at the damsite include: a) bucket auger drill holes along the upstream and downstream toe of the dam to delineate the lateral extent of the original streambed of Dry Creek, b) bucket auger drill holes in the Dry Creek channel upstream of the dam to determine quantities and soil properties for potential filter material, c) an auger drill hole with SPT's developed into an observation well in the reservoir area to monitor subsurface flows along Dry Creek, d) an auger drill hole with SPT's developed into an observation well at the foundation of the proposed Big Dry Creek Outlet Works, and e) an auger drill hole with SPT's developed into an observation

well on both the upstream and downstream toe of the dam in the original Dry Creek streambed to monitor ground water movement.

40. Fancher Creek Dam and Reservoir. -

a. Geologic and Soils Investigations. - The Fancher Creek Dam and reservoir site was investigated in September 1982, August 1983, and July 1984. The 1982 explorations included 12 borrow trenches, 5 foundation trenches, and 11 undisturbed sample holes. The undisturbed sample holes were drilled to refusal or maximum depths of 20 feet to obtain material for laboratory testing. In 1983, three additional holes were drilled to determine the depth to bedrock in areas where basement material was not encountered during the 1982 drilling. These drill holes were located in old stream channels of Fancher and Hog Creeks. Explorations in 1984 included four borrow trenches and two auger drill holes with SPT's. The trenches were excavated in an area previously inaccessable due to rights-of-entry conflicts. The auger holes were drilled to examine fill material at the abutments of a small bridge crossing the flume at Fancher Creek. The location of explorations is shown on Plate F6.

b. Geologic Conditions. - The proposed Fancher Creek Dam site is underlain by moderately to highly weathered igneous rock ranging from granodiorite to gabbro, shown on Plate F6. The granitic rock is capped by a thin veneer of silty sand, sandy silt, and gravelly sand over most of the reservoir area. Explorations indicate highly weathered or decomposed granite occurs generally within 2 to 10 feet of the surface, and grades downward to moderately weathered. Along old stream channels of Fancher and Hog Creeks, depths to weathered rock were found to be generally less than 35 feet.

c. Foundation Conditions. -

(1) Soil Types. - Foundation soils in the Fancher Creek project area consist of streambed alluvial deposits and residual soils underlain by decomposed granite. Thicknesses of the soil range from a few inches at the abutments to over 30 feet in the creek channels. Materials comprising these surficial deposits consist mainly of sands, silts, and clays, Plate F7. The average gradation of 40 samples analyzed for grain size distribution indicates 51% fines, 47% sand, and 2% gravel. Soil plasticities ranged from non-to high, with low to medium constituting a majority of the values, Plate F16. Little or no cementation was reported. Gradations of the decomposed granite were significantly coarser than those of the alluvial and residual soils. The average gradation of 47 samples of weathered granite consisted of 78% sand, 12% gravel and 10% fines. Mineral components included quartz, feldspars, mafics, and biotite. Plasticities were generally low, with weathering moderate to high.

(2) Penetration Resistance. - Very few SPT's were conducted, so consistencies and densities have been generally based on field observations. Relative densities of the sands ranged from loose to very dense, with a majority of the values classified as firm. Consistencies of the fines varied from firm to hard.

Explorations at both abutments of the existing bridge, which spans the Fancher Creek flume, encountered uncharacteristic loose and soft soils from the Friant-Kern Canal levee foundation and embankment. Strata of unfavorable materials ranged from 7.5 to 13 feet in boring 2F-1 and from 5 to 8.5 feet and 11 to 20.5 feet in boring 2F-2, Plate F9. SPT results conducted on these materials averaged less than 5 blows for a 1-foot advancement of the sampler. Silts were generally classified as soft (N = 2-4), while sands were loose (N = 5-10).

d. Borrow Area Conditions. - As with foundation materials, borrow area materials can be divided into alluvial soil, residual soil and decomposed granite. Soils varied from sandy clay (CL-CH) to sandy silt (ML-MH) with lesser amounts of clayey sand (SC) and silty sand (SM), Plate F19. The composite gradation of 12 samples consisted of 43% sand and 57% fines. Plasticities varied from non-to high. Generally, high plasticity materials were encountered in surface deposits. Depths of these deposits ranged from a few inches to a couple of feet. Low plasticity soil ranged in thickness from a few feet to approximately 30 feet. The shallow deposits are located at the higher elevations of the flood pool, while the deeper deposits are found in the existing Fancher Creek channel near the axis of the proposed embankment. Decomposed granite underlies the soil deposits. Undisturbed samples of decomposed granite broke down to, clayey sand (SC), silty sand (SM), gravelly sand (SP-SW) or sand (SW-SP). The average gradation of 18 samples tested for grain-size distribution contained 78% sand, 14% gravel, and 8% fines. Plasticities ranged from non-to medium. Mineral components of the decomposed granite included quartz, feldspar, mafics and biotite.

The proposed borrow areas for Fancher Creek Dam are shown on Plate F6. Based on the results of the initial exploration programs conducted, it is projected that the top 0.5 to 1.5 feet of material will be stripped, with one quarter of this material stockpiled for borrow area restoration, and the remainder wasted in the low lying areas at the upstream toe of the dam. The next 1.0 to 3.0 feet of cut will be used as impervious fill. Material excavated after removal of the impervious fill will be utilized as random fill. Depths of excavations will be limited such that water pooling impacts are minimal. A finalized excavation and drainage plan will be forestalled pending completion of a detailed site specific exploration program, described in paragraph 41h.

e. Ground Water. - Ground water levels varied throughout the Fancher Creek project site. Water was not encountered in the northern reaches of the project, and varied from 8 to 14 feet along the Fancher Creek drainage. Ground water depths along the proposed dam centerline ranged from the ground surface, where ponding exists, to approximately 19 feet deep. Surface ponding is confined to the low area immediately upstream of the existing Fancher Creek overchute of the Friant-Kern Canal. Since this pool is perennial, adjacent areas will be saturated. The water table depth was measured at 19 feet below ground surface near the existing siphon which passes under the Friant-Kern Canal at canal Station 1072+52. The extent of seasonal ground water fluctuation is unknown, but future installation of piezometers is planned to collect data for future designs and construction.

In order to control ground water during construction, the embankment toe drain should be installed at the beginning of the construction sequence.

f. Laboratory Test Results. -

(1) Laboratory Testing Program. - Extensive primary and secondary laboratory testing was performed on foundation and borrow materials. Testing included grain-size analysis, Atterberg limits, specific gravity, compaction, consolidation, permeability, direct shear, triaxial compression, unconfined compression, shrinkage limit, water content, and dry unit weight, Plates F16 through F21. Testing methods conformed to procedures described in EM 1110-2-1906 (Laboratory Soils Testing, 30 November 1979). Soil samples were classified in accordance with TM No. 3-357, Appendix A (The Unified Soil Classification System, April 1960, reprinted May 1967).

(2) Summary of Laboratory Test Results. - A summary of primary laboratory test results for Fancher Creek Dam is shown in Table 22. Included in the table are the range of results as well as average values. Table 23 indicates the summary of secondary test results and selected design values.

(3) Selected Design Values. - Based upon laboratory testing, the following design values were selected for Fancher Creek Dam embankment, random fill, impervious fill, and filter and drainage material. The allowable bearing capacities of the soil were calculated from EC 1110-2-1903 and compared to required bearing capacities for the design of the concrete structures in accordance with EM 1110-2-2502 (Retaining Walls) to ensure foundation adequacy.

(a) Embankment Foundation. - The design values for alluvial and residual soils are shown below:

Parameter	Design Value		
Dry Unit Weight	109.2	PCF	
Moist Unit Weight	129.3	PCF	
Saturated Unit Weight	132.2	PCF	
Submerged Unit Weight	69.9	PCF	
Unconsolidated-Undrained "Q" Strength	C = 1000	PSF	Ø = 33°
Consolidated-Undrained "R" Strength	C = 1000	PSF	Ø = 21°
Consolidated-Undrained "S" Strength	C = 0		Ø = 36°
Coefficient of Permeability, $\bar{k}$	1	FPD	
Specific Gravity	2.75		

Table 22

Fancher Creek Dam
Summary of Primary Laboratory Test Results

Material	Predominant Soil Class	Avg. Soil Fraction% Gravel	Sand	Fines	Atterberg Limits Liquid Limits	Plas. Index	Moisture Content %	Field Density (PCF)	Remarks
Foundation Material									
Fat Clays	CH	-	33	67	54	38	22.8	100.9	1 Test Only
Residual & Alluviul Soil	SC	0-84	14-96 53	2-79 47	13-47 31	1-27 11	2.5-25.1 14.5	100-134.1 129.3	----
Decomposed Granite	SC-SW	0-68 8	46-97 81	3-53 11	0-40 30	NP-19 7	4.5-15.7 9.1	122.6-148 142.4	----
Borrow Material									
Fat Clays	CH	0-25 13	18-28 23	57-72 64	54-72 58	35-50 39	----	---	3.0' Max. Depth
Impervious Fill (Soil)	SC	0-25 0	51-67 53	33-48 47	20-39 28	6-16 11	1.0-24.0 13.4	---- ----	----
Random Fill (D.G.)	SC-SW	6-27 8	68-90 81	4-27 11	31-40 36	10-19 14	2.0-11.0 6.7	----	----

Table 23

Fancher Creek Dam
Summary of Secondary Laboratory Test Results

Material	Standard Compaction 95% / Opt W (PCF) (%)	Range of Shear Strengths: Direct (S) Ø	Direct (S) c(PSF)	Triaxial (R) Ø	Triaxial (R) c(PSF)	Triaxial (Q) Ø	Triaxial (Q) c(PSF)	Coeff. of Permeability Kv (Ft/Day) (Avg.)	Gs	Remarks
Fat Calys	----	--	--	--	--	--	--	--- 0.1	--	Waste
Residual & Alluvial Soil	----	36-41 36	-- 0	-- 21°	-- 1,000	-- 33°	-- 1,000	-- 0.5	2.75	Undisturbed
Decomposed Granite	----	-- 42°	-- 0	-- 26°	-- 1,000	-- 44°	-- 0	-- 0.05	2.85	Undisturbed
Fat Calys	97.9/18.8	--	--	--	--	--	--	--	--	Waste
Impervious Fill (Soil)	118.6/11.0	-- 34°	-- 0	-- 17°	-- 0	-- 10°	-- 1,000	-- 0.05	2.73	Remolded
Random Fill (D.G.)	118.5/10/6	36-39 36°	-- 0	13-18 13°	-- 800	-- 23°	800-1,200 800	0.05	2.75	Remolded

(b) Foundation Decomposed Granite. - Decomposed Granite strengths shown below will vary depending upon degree of weathering.

Parameter	Design Value		
Dry Unit Weight	130.5	PCF	
Moist Unit Weight	142.4	PCF	
Saturated Unit Weight	147.4	PCF	
Submerged Unit Weight	85.0	PCF	
Unconsolidated-Undrained "Q" Strength	C = 0		Ø = 44°
Consolidated-Undrained "R" Strength	C = 1000	PSF	Ø = 26°
Consolidated-Undrained "S" Strength	C = 0		Ø = 42°
Coefficient of Permeability, $\bar{k}$	0.1	FPD 1/	
Specific Gravity	2.85		

1/ Based on values for similiar Decomposed Granite

(c) Random Fill. - Materials tested were taken from a composite of typical Decomposed Granite. Unit Weights are for 95% standard density. Strength tests were conducted on samples remolded to 90% standard density at ± 2% of optimum moisture content. Selected design values are minimums experienced over the range tested. Additional strength tests will be conducted on samples remolded to 95% of standard density. FDM design analyses will be based on the revised strengths established.

Parameter	Design Value		
Dry Unit Weight	118.5	PCF	
Moist Unit Weight	131.0	PCF	
Saturated Unit Weight	137.8	PCF	
Submerged Unit Weight	75.4	PCF	
Unconsolidated, Undrained "Q" Strength	C = 800	PSF	Ø = 23°
Consolidated, Undrained "R" Strength	C = 800	PSF	Ø = 13°

Parameter	Design Value		
Consolidated Drained "S" Strength	C = 0		Ø = 36°
Coefficient of Permeability, $\bar{k}$	1	FPD	
Specific Gravity	2.75		

(d) Impervious Fill. - Surface soils, excluding fat clays, were remolded to 95% standard density at 2% wet of optimum moisture content, as shown below:

Parameter	Design Value		
Dry Unit Weight	118.6	PCF	
Moist Unit Weight	131.6	PCF	
Saturated Unit Weight	137.6	PCF	
Submerged Unit Weight	75.2	PCF	
Unconsolidated, Undrained "Q" Strength	C = 1,000	PSF	Ø = 10°
Consolidated, Undrained "R" Strength	C = 0		Ø = 17°
Consolidated, Drained "S" Strength	C = 0		Ø = 34°
Coefficient of Permeability, $\bar{k}$	0.1	FPD	
Specific Gravity	2.73		

(e) Filter Material and Drainage Fill. - The design values shown below were based on known properties of processed sand and gravel.

Parameter	Design Value	
Dry Unit Weight	115.0	PCF
Moist Unit Weight	125.0	PCF
Saturated Unit Weight	130.0	PCF
Submerged Unit Weight	67.6	PCF

Parameter	Design Value	
Unconsolidated-Undrained "Q" Strength	C = 0	Ø = 36°
Consolidated-Undrained "R" Strength	C = 0	Ø = 36°
Consolidated-Drained "S" Strength	C = 0	Ø = 36°
Coefficient of Permeability, $\bar{k}$	1,000 FPD	
Specific Gravity	2.65	

g. Design Analysis. - A description of the proposed typical embankment sections, seepage control features, and excavation and fill quantities is in Chapter IV - Description of the Selected Plan.

(1) Slope Stability. - A stability analysis was performed on the embankment using the circular arc method as described in EM 1110-2-1902 (Stability of Earth and Rockfill Dams, 1 April 1970). The analysis was performed on the Harris computer system using Program No. 741XL62040, developed by the St. Paul District, Corps of Engineers. The circular arcs with the critical factor of safety were then checked manually using the Modified Swedish Method, Finite Slice Procedure. Stability analysis performed for end of construction, steady seepage, partial pool, and sudden drawdown conditions are shown on Plates F22 through F25. A pseudo static seismic loading condition, using a seismic coefficient of 0.1, was used to analyze seismic stability for the end of construction, steady seepage and partial pool conditions. Table 24 shows the minimum required and computed factors of safety.

Table 24

Fancher Creek Dam, Slope Stability Factors of Safety

Design Condition	w/o Seismic Loading		With Seismic Loading	
	Minimum Required	Computed	Minimum Required	Computed
End of Construction	1.3	2.1	1.0	1.6
Partial Pool	1.5	2.1	1.0	1.4
Steady Seepage	1.5	1.5	1.0	1.3
Sudden Drawdown	1.2	1.2	N/A	----

When analyzing the Fancher Creek Dam embankment for slope stability, foundation materials were assumed to be homogemous. Design strengths were based upon a specimen of clayey sand (SC-SM) having 51% sand and 49% fines. Such a gradation is indicative of average foundation materials encountered.

Based upon the results of the exploration programs conducted, a majority of the foundation material would appear to have strengths greater than or equal to those choosen for design. The only area of concern was in the vicinity of boring 7F-11. However, based on a preliminary evaluation of the most recent (FDM) explorations, this concern seems unwarranted.

Based on this reevaluation of foundation conditions, and noting the high factors of safety calculated for slope stability, any conceivable foundation strength variation will have little affect on the proposed design section. If localized zones of weaker than expected foundation materials are encountered, potential stability problems will be rectified through over excavation of the suspect materials. Additional field work will be conducted in the area adjacent to boring 7F-11 to insure such foundation treatment is not required along this reach of the project.

The design strengths for the impervious materials were based upon a composite having a gradation with 49% fines. Though this material represents the coarser 10 percentile of all the surficial soils tested, its gradation is very close to the average. If a less conservative "R" strength been chosen, concern could have been expressed that the selected design strengths are non-representative and potentially non-conservative. However, since the cohesion intercept for the design "R" strength was set equal to zero, the impervious fill design strength defaults to the average of the "R" and "S" strengths ($\emptyset$=25.5°) for the steady seepage and partial pool conditions, and to the "R" strength ($\emptyset$=17°) for the sudden drawdown case. If the cohesion intercept for the impervious fill "R" strength not been set to zero, a "S" strength of $\emptyset$=34° would have been used for low stress conditions. Since induced stresses on impervious fills are limited to approximately 1 KSF, and the actual intersection of the "R" and "S" strengths can realistically be assumed to occur at higher stresses than those expected, the use of the "R" strength or the average of the "R" and "S" strengths for low stresses are conservative for even the most fine grained soils. Since the selected design strengths are safe, no additional shear testing of impervious fills will be conducted.

(2) Seepage. - A flow net analysis, conducted on a typical section of Fancher Creek Dam, is shown on Plate F26. Assuming steady seepage conditions develop as a result of long term storage at gross pool, total seepage through the dam and foundation is estimated at 1.1 cfs. This seepage flow will be collected in the horizontal and toe drains, and routed away from the project by way of an outfall pipe under the Friant-Kern Canal.

(3) Settlement. - A settlement analysis was performed based upon Terzaghi's consolidation theory. At maximum section, a total settlement of 6 inches was estimated, with over 70 percent of this total occurring during construction. Of this 6 inches, it is anticipated that the foundation will settle about 2-3/4 inches and the embankment about 3-1/4 inches. Only 1-3/4 inches of post construction settlement is estimated. Therefore, the crest of the dam will not be cambered to compensate for settlement.

(4) Fancher Creek Overchute Bridge Foundation. - A pile foundation is recommended for this structure. Pile depths will average 30 feet and bear

on Decomposed Granite. Piles are necessitated by the unsuitable loose sands and soft silts encountered at either abutment. Depths of these sands and silts range to 13 feet in boring 2F-1 and to 20.5 feet in boring 2F-2.

h. Proposed Geologic and Soils Investigations. - Additional explorations will be conducted at the Fancher Creek Dam site to more fully evaluate foundation and borrow area conditions. Foundation work will consist of 8 auger holes drilled to refusal. Four of the holes will be converted to piezometers upon completion of drilling. Standard Penetration Tests will be conducted at half of the sites to evaluate material consistencies and densities. A hand-held power auger will be used to further explore the borrow area. The purpose of the program will be to classify surficial soils and establish depth to decomposed granit. Borrow area work will consist of at least 18 auger holes as shown on Plate F6. Completion of the exploration program will allow for a more detailed formulation of borrow area excavation and drainage plans.

41. Pup Creek Detention Basin. -

a. Geologic and Soils Investigations. - Explorations for the proposed Pup Creek detention basin were conducted in August, 1983. The exploration program included two 15-foot-deep auger drill holes with SPT's and three backhoe borrow trenches as shown on Plate P7. Auger holes 2F-6 and 2F-7 were designed to investigate the foundation conditions at the spillway and the outlet works. Trenches 4B-17, 4B-18, and 4B-19 were located in the basin area and were designed to help determine the subsurface soil properties, indicated on Plate P6.

b. Geologic Conditions. - The detention basin is underlain by soils primarily derived from a granitic source and include sandy clay (CL), clayey sand (SC), silty sand (SM), and sandy silt (ML), shown on Plates P9 and P10. Explorations indicate most of the detention basin is underlain by a prominent hardpan layer. Logs of exploration indicate the material is laterally discontinuous, with a 1 to 9-foot thickness of slightly to moderately cemented silty sand except in hole 2F-7. Logs of trenches 4B-18 and 4B-19 indicate the cemented material extends to at least 12 feet in depth.

c. Foundation Conditions. -

(1) Soil Types. - Foundation soils in the proposed Pup Creek Detention Basin are generally silty sands (SM) to clayey sands (SC), with a few layers of sandy clays (CL) and sandy silts (ML), Plate P6. The average gradation of nine samples analyzed for grain size distribution consisted of 60% sand, 38% fines and 2% gravel. Plasticities ranged from low to medium, as indicated on Plate P8. Cementation varied from non-to moderate, as indicated on Plate P7.

(2) Penetration Resistance. - The relative density of the cohesionless soils range from very firm to very dense (N = 29 to Refusal), while the cohesive soils have consistencies of very stiff to hard (N = 25 to 48)

d. Ground Water. - Ground water was not encountered during explorations in the Pup Creek Detention Basin area.

e. Summary of Laboratory Test Results. -

(1) General Testing. - Primary and secondary laboratory testing was conducted on foundation materials. Testing included grain-size analysis, Atterberg limits, water content, compaction, and specific gravity, Plate P8. Testing methods conformed to the procedues described in EM 1110-2-1906 (Laboratory Soils Testing, 30 November 1970). The soil was classified in accordance with TM 3-337, Appendix A Unified Soil Classification System, (April 1960, reprinted May 1967).

(2) Selected Design Values. -

(a) Foundation. - Based on field observations and SPT results, a foundation strength of $\emptyset$=35° was selected for Pup Creek Detention Basin. The bearing capacity was based on this strength and was calculated to be 3.4 ksf for design of the concrete structures.

(b) Borrow Material. - Borrow material will have the properties listed below. Unit weights shown are for 95% standard density. The consolidated-drained "S" strength was estimated based upon tests of similiar materials from Big Dry Creek Dam.

Parameter	Design Value
Dry Unit Weight	112.2 PCF
Moist Unit Weight	127.6 PCF
Saturated Unit Weight	133.8 PCF
Submerged Unit Weight	71.4 PCF
Consolidated-Drained "S" strength	C = 0 $\emptyset$=33°
Specific Gravity	2.75

f. Design Analysis. -

(1) Seepage. - Since the basin will be excavated below grade and the invert elevation lies in impervious "Hardpan" layers, seepage from Pup Creek Detention Basin will be negligible.

(2) Settlement. - Settlement of the outlet works is not anticipated. Foundation materials have high consistencies and densities, and the projected design loads are low.

(3) Slope Stability. - Design slopes are flat, and heights of cuts are minimal; slope stability will not be a problem. Basin side slopes of 1V on 8H reflect requirements requested by the Local Sponsor, and are not characteristic of slope stability problems.

g. Proposed Geologic and Soils Investigations. - Exploration at the detention basin will be conducted to determine foundation conditions at the proposed inlet. The explorations will consist of three 15-foot-deep auger

holes with SPT. Results of the exploration program will be used to evaluate the need for soil cement at the basin inlet. In addition, secondary testing will be completed to determine the feasibility of using soils excavated at the Pup Creek Detention Basin in Big Dry Creek Dam embankment.

42. Alluvial Drain Detention Basin. -

a. Geologic and Soils Investigations. - Explorations at the proposed Alluvial Drain Detention Basin were conducted during August, 1983. Three backhoe borrow trenches (4B-14, 4B-15, and 4B-16) and two auger drill holes with SPT's (2F-8 and 2F-9) were designed to investigate the basin area and the foundation conditions under the proposed spillway and outlet works. The location of these explorations are shown on Plate A5. Inaccessability to the scheduled auger hole sites required that the locations be moved to the access road along the Enterprise Canal. Additional footage was required to allow for drilling through the embankment into native material.

b. Geologic Conditions. - The detention basin is underlain by loose to slightly cemented alluvial material. Like the material at the Pup Creek Detention Basin, the soils were derived primarily from granitic sources. Laboratory classifications of the soils include clayey sand (SC), sandy clay (CL), and silty sand (SM). The hardpan layer evident in much of the eastern Fresno County area was absent in explorations conducted at this site.

c. Foundation Conditions. -

(1) Soil Types. - Soils encounterd during explorations in the proposed Alluvial Drain Detention Basin area were mainly clayey sands (SC) and silty clayey sands (SM-SC), Plates A5 and A6. Average sand content was approximately 62%, with fines constituting all but a trace of the remainder of the sample. Fines were all of low plasticity, as indicated on Plate A7. Cementation ranged from non to slight.

(2) Penetration Resistance. - SPT's conducted in the hollow stem auger explorations (2F-8 and 2F-9), indicate that the top 7 to 10 feet of the material encountered was very loose to loose, while deeper material ranged from firm to very dense, with a majority of the material classified as very dense. The loose to very loose surface soils consist of fill placed during the construction of the Enterprise Canal banks, while deeper, denser soils represent foundation conditions below the original ground surface.

d. Ground Water. - Ground water was not encountered during explorations in the Alluvial Drain Detention Basin area.

e. Summary of Laboratory Test Results. -

(1) General Testing. - Primary and secondary laboratory testing was conducted on foundation materials. Testing included grain-size analysis, Atterberg limits, compaction, water content, and specific gravity, Plate A7. Testing methods conformed to the procedues described in EM 1110-2-1906 (Laboratory Soil Testing, 30 November 1970). The soils were classified in

accordance with the TM 30337, Appendix A, Unified Soil Classification System (April 1960, reprinted May 1967).

(2) Selected Design Values. -

(a) Foundation. - An allowable foundation bearing capacity of 3 KSF is recommended for Alluvial Drain Detention Basin design purposes. This value is based upon SPT results obtained in the vicinity of the outlet works.

(b) Borrow Material. - Borrow soils will have the properties listed below. Unit weights are for 95% standard density. The consolidated-drained "S" strength was estimated based upon tests of similar materials from Big Dry Creek Dam.

Parameter	Design Value
Dry Unit Weight	109.2 PCF
Moist Unit Weight	125.0 PCF
Saturated Unit Weight	131.9 PCF
Submerged Unit Weight	69.5 PCF
Consolidated-Drained "S" strength	C = 0, Ø=33
Specific Gravity	2.75

f. Design Analysis. -

(1) Seepage. - Seepage will not be a problem since the basin will be excavated below grade. However, subsurface seepage might develop along the contacts of dense to very dense foundation layers.

(2) Settlement. - Settlement of the outlet structure will not be a problem since design loads are minimal.

(3) Slope Stability. - All design slopes are gentle and cut heights minimal, so slope stability will not be a problem. Basin side slopes of 1V on 8H reflect requirements requested by the FMFCD, and are not characteristic of slope stability problems.

g. Proposed Geologic and Soils Investigations. - Exploration at the detention basin will be conducted to determine foundation conditions at the proposed inlet slope protection structure. The explorations will consist of three 15-foot deep auger holes with SPT. Results of this exploration program will be used to evaluate the need for soil cement at the basin inlets. In addition, secondary testing will be completed to determine the feasibility of using soils excavated at the Alluvial Drain Detention Basin in Big Dry Creek Dam embankment.

43. Redbank Creek Detention Basin. -

a. Geologic and Soils Investigations. - The proposed Redbank Creek Detention Basin foundation and borrow area was investigated in August 1983 and July 1984. Exploration in 1983 included three backhoe borrow trenches

(4B-20, 4B-21, and 4B-22) and five auger drill holes with SPT's (2F-1 through 2F-5). The auger drill holes were designed to investigate foundation conditions at the then proposed siphons, outlet works conduits, inlet weir, and headworks. Structural design changes required the additional investigations in 1984. Ten additional auger holes with SPT's (2F-13 through 2F-22) were drilled along the existing and proposed rerouting alignment of Mill Ditch. Constant-head permeability tests were conducted on holes 2F-15 and 2F-18. Upon completion of drilling and testing, holes 2F-15, 2F-16, 2F-19, and 2F-22 were converted to observation wells for future groundwater observation. The location of the explorations are shown on Plate R7.

b. Geologic Conditions. - The proposed detention basin is underlain by very loose to moderately cemented alluvial material derived from erosion of the granitic basement rock of the Sierra Nevada Range. Explorations indicate much of the detention basin is underlain by a discontinuous layer of slightly to moderately cemented silty sand hardpan. The hardpan was encountered in holes 2F-1, 2F-17, 2F-19, 4B-20, and 4B-21 at depths between 2.5 and 12 feet, and is exposed along the stream bank of Mill Ditch between DeWolf Avenue and the confluence of Mill Ditch and Redbank Creek, as shown on Plates R6 thru R9. Constant-head permeability tests were conducted in holes 2F-15 and 2F-18. The testing program indicates the subsurface to be essentially impervious at those locations. Hole 2F-15 required 15 gallons of water to maintain a constant head over a 165-minute time period, while hole 2F-18 required 10.4 gallons for 165 minutes.

c. Foundation Conditions. -

(1) Soil Types. - Extensive explorations of subsurface deposits in the Redbank Creek Detention Basin area established foundation conditions. Soils consist predominantly of silty sand (SM) with lesser amounts of clayey sand (SC), sandy silt (ML), sandy clay (CL), and clean sand (SP), Plate R6. Contents of samples analyzed for grain-size distribution averaged 65% sand and 35% fines. Plasticities ranged from non-to low, while cementation varied from non-to well, as indicated on Plate R11. A soil profile along the proposed realignment of Mill Ditch is shown on Plate R6.

(2) Penetration Resistance. - Existence of cemented "Hardpan" layers were responsible for the wide fluctuation of SPT results. The relative density of the cohesionless soils ranged from very loose to very dense (N = 3 to refusal), while consistencies of cohesive soils ranged from firm to hard (N = 8 to refusal). Orientation of dense "Hardpan" layers were localized with no continuous basin wide trends discernable.

d. Ground Water. - Ground water was encountered during foundation explorations. Depth to water varied. However, existence of saturated conditions is related to the proximity of Mill Ditch and Redbank Creeks. Of the explorations conducted away from Mill Ditch and Redbank Creek, only 2F-15, 18, 19 and 4B-20 encountered water. Ground-water levels in 2F-15 and 2F-19 were below the proposed basin invert, while water encountered in trench 4B-20 is believed to represent perched water fed by surface infiltration. Water encountered in boring 2F-19 also seems to be perched. Field logs for

this hole identified a dense silty sand (SM) layer that acts as an aquitard, limiting flow into underlying dry to damp, very loose to loose materials.

Observation wells were installed at the locations shown on Plate R7. Their existence will allow for a more detailed evaluation of seasonal ground-water fluctuations. However, information gathered to date indicates that the proper sequence of ditch and basin excavation, along with a creek diversion plan, will avoid potential ground water problems.

e. Laboratory Test Results. -

(1) Laboratory Testing Program. - Primary and secondary testing was conducted on foundation materials. Testing included grain-size analysis, Atterberg limits, water content, compaction, and specific gravity. Additional primary laboratory testing is being conducted on soils sampled along the proposed rerouted Mill Ditch. Testing methods conformed to the procedures described in EM 1110-2-1906 (Laboratory Soil Testing, 30 November 1970). The soils were classified in accordance with TM 3-337, Appendix A, Unified Soil Classification System (April 1960, reprinted May 1967).

(2) Selected Design Values

(a) Foundation. - Based on SPT results conducted in the vicinity of the structure, a consolidated-drained "S" strength of Ø=37° was selected for Redbank Creek Detention Basin foundation and used to develop bearing capacities. The bearing capacity used for the design of the concrete structures is 4.5ksf.

(b) Borrow. - Borrow soils will have the properties listed below. Unit weights shown are for 95% Standard density. The consolidated-drained "S" strength was estimated based upon tests of similar soils from Big Dry Creek Dam.

Parameter	Design Value	
Dry Unit Weight	114	PCF
Moist Unit Weight	128	PCF
Saturated Unit Weight	135	PCF
Submerged Unit Weight	72.6	PCF
Consolidated-Drained "S" Strengt	C=0 Ø=33°	
Specific Gravity	2.75	

f. Design Analysis. -

(1) Seepage. - Since the basin will be excavated below grade, surface seepage is not anticipated. Seepage between rerouted Mill Ditch and the detention basin will be negligible due to the small maximum potential gradient between the two. Dense "Hardpan" layers will limit vertical percolation.

(2) Settlement. - Settlement of the water control structure will not be a problem. The foundation will be founded on dense sands, and will be buried a minimum of 3.5 feet below final grade.

(3) Slope Stability. - Fill slopes are mild and cut heights minimal so slope stability will not be a problem. Basin side slopes of 1V on 8H reflect requirements imposed by the Local Sponsor, and are not indicative of slope stability problems.

g. Proposed Geologic and Soils Investigations. - Additional explorations are scheduled at the detention basin to provide foundation information for the downstream control structure to be located on Redbank Creek. The exploration will consist of two 40-foot deep auger holes located at the abutment of the proposed structure, adjacent to the old existing hole 2F-20. If field conditions permit, one auger hole will also be drilled in the creek bottom at the control structure site.

44. Slope Protection. -

a. Dams. - Both riprap and turfed earthen slopes were investigated for Big Dry and Fancher Creek Dam slope protection requirements. Riprap designs consistent with Appendix C of EM 1110-2-2300 produced a minimal layer thickness which was less than the minimum practical for placement. Since any rock protection that could be built would be both excessive and expensive, a careful analysis considering pertinent topics was conducted. Factors considered included the nature of the embankment materials to be protected, the ease of access for maintenance, the availability of materials for use as slope protection, duration of exposure, and past operational performance of Big Dry Creek Dam and other facilities in the project vicinity. Based on this study the following slope protection provisions are proposed for Fancher Creek and Big Dry Creek dams.

(1) Big Dry Creek Dam. - The upstream and downstream slopes will be protected by a combination of turf and erosion resistant clayey sand (SC). Additional crest protection will be provided by a ten-foot horizontal width section of sandy clay extending from elevation 437.4 to the dam crest. Material for this section will be obtained from the Fancher Creek Dam borrow area. Transportation of this material will be coordinated with proposed hauling of filter material from the Big Dry Creek Dam site to the Fancher Creek Dam site. Downstream slope protection will be provided by turf. Specifications will require contractor to establish turf protection before before the advent of winter rains.

Support for this slope protection design can be found in the operational performance of existing Big Dry Creek Dam. This dam, which was constructed of similar clayey sand (SC) and turfed with grass, has performed with no sign of embankment erosion during its 37 years of existance. Since operational procedures will not change, and the embankment slopes of the expanded dam are flatter than those of the existing dam, it is logical to assume that the enlarged dam will resist erosion better than the existing dam. However, if the upstream slope was to suffer minor benching or erosional damage, the flat slopes will insure ease of access for maintenance during summer months.

(2) Fancher Creek Dam. - A 10-foot horizontal width of sandy clay (CL), seeded with turf, will blanket the upstream slope of the embankment. This zone will extend from the base to the crest of the dam. Sandy clay used for this zone will have a liquid limit between 40 and 50, and will plot above the "A" line. Benching of this material is not anticipated. However, if minor erosional damage were to occur, the relatively flat upstream slopes will afford easy maintenance access during dry summer months.

Downstream slope protection will be provided by turf. Specifications will require contractor to establish turf protection before before the advent of winter rains.

b. Detention Basins. - Erosion protection materials are needed at each detention basin. Alluvial Drain Detention Basin has two inlets for low volume flows and an additional section that functions as an inlet during flood floods. Pup Creek Detention Basin has one inlet section that experiences both low and high flood flows. Additionally, Pup Creek Detention Basin has a low retention embankment at the southwest corner of the basin that could be subjected to over topping during a flood event greater than the 200-year design event. The construction of Redbank Creek Detention Basin will include embankment and channel slopes that will need erosion protection, as shown on Plate R1.

(1) Erosion Protection Costs. - A comparison was made of the first cost of various materials that could be used to protect a typical section of channel or embankment. Materials considered were riprap, gunnite, concrete block, gabions, and soil cement. The study indicated that based on required performance, soil cement was the least cost option. A factor in selecting soil cement is the reduced excavation requirement due to no bedding requirement to prevent migration of fines. In addition to this analysis, a comparison of the cost of soil cement to the cost of gunnite, presented in "Soil Cement in Energy and Water Resources" (PCA, nd), shows the cost of soil cement to be lower. While soil cement blends well into the surrounding ground and is asthetically more pleasing than some other forms of erosion protection its performance under conditions expected for this project are not well known at this time. Further studies during feature design work will be carried out to confirm its use or a replacement that will meet the design requirements.

(2) Design Criteria. - After consultation among the Civil Design, Soils Design, and Hydraulic Design sections and an inhouse literature review, it appears that no firm guidance is available to establish the thickness of soil cement required for project design conditions. In lieu of established guidelines, guidance was sought from the Arizona Department of Transportation (DOT), Flood Control Section. Their experience with soil cement indicates that soil cement can sustain high velocity flows for long periods of time without significant damage. The soil cement sections they used were 6 to 8 feet thick for flow velocities sustained at 14 fps. For the infrequent overtopping flow expected at Redbank and Pup Creek basins, they recommend a thickness of 2 feet. It is thought that a soil cement section less than 2 feet would result in local areas less than the specified thickness.

(3) Inlet Erosion Protection. - The portions of cut slope at inlets to Alluvial Drain and Pup Creek Detention Basins which are subjected to high flows during flood events will be protected by an 8-inch thick layer of soil cement, placed on the compacted cut slope. The soil cement plate will be keyed into the shoulder of Locan Avenue (Pup Creek) and Temperance Avenue (Alluvial Drain) 10 feet from the downstream edge of the road. The inlet cut slopes will be 1V on 4H rather than the 1V on 8H slope of the rest of the basins, to reduce material requirements. The soil cement will be placed and compacted parallel to the cut inlet slope to form a single 8-inch thick layer extending to 2 feet below the invert of the basin. Such a section is considered adequate due to the low frequency of large volume long duration flood flows, the relative cost of maintenance versus a thicker design section, and the anticipated satisfactory performance of the section when subjected to maximum design velocities on the order of 7.5 fps.

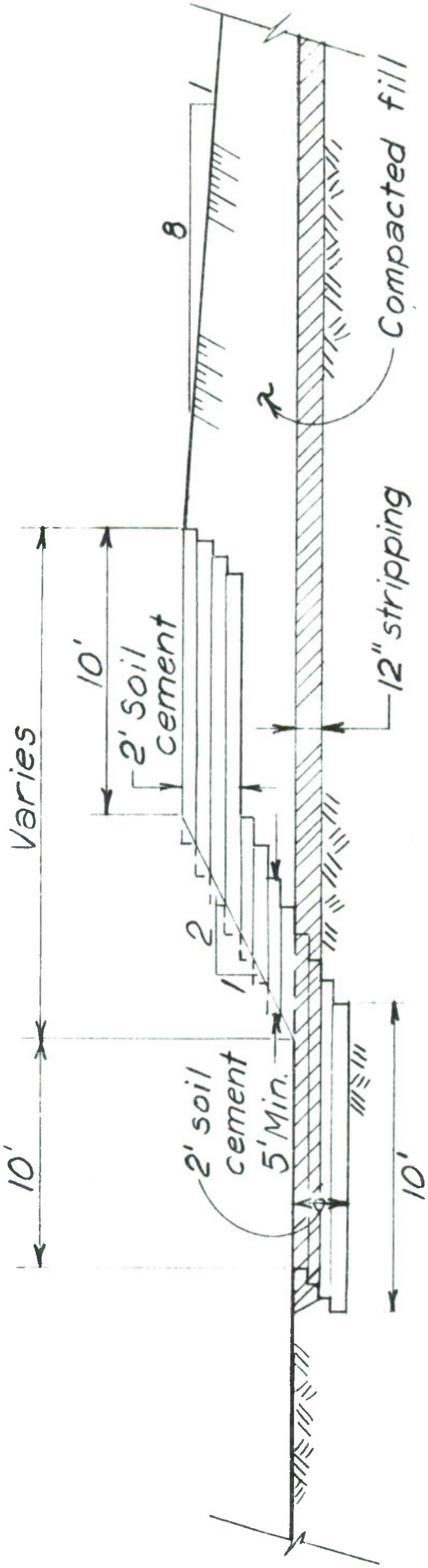
(4) Embankment Protection. - The embankments required at Pup Creek and Redbank Creek Detention Basins will be composed of soil cement and engineered fill, Figure 2. The embankments will be constructed by placing the soil cement and engineered fill in a single operation. This should minimize separation of the layers. For each layer, the soil cement will be compacted against a previously placed and compacted soil layer. The soil cement portion of an embankment will tie into an apron slab just downstream. The top of the apron is to be at the same elevation as the ground surface. The soil cement portion of embankments will have a 1V on 2H slope. All embankment soil cement sections will be measured normal to the sloping surface. Flow velocities over the detention basin embankments are estimated to be less than 14 fps. These flows would occur during events less frequent than a 200-year recurrance event. Local flows parallel to the embankments may potentially erode material away from the apron, however, the apron is to be keyed into the ground to a depth of 2 feet and with proper inspection and maintenance any problems should be eliminated.

(5) Mill Ditch Erosion Protection. - Based on the experience and recommendations of Arizona DOT, soil cement will not be used in rerouted Mill Ditch. Rather, revet mattress and bedding or gabions will be utilized to prevent scour and erosion at channel bends.

45. Concrete Materials. -

a. Concrete Requirements. - Construction of the Redbank and Fancher Creeks project will require an estimated 9,400 cubic yards of high quality concrete and 7,900 cubic yards of mass and lean mix concrete. The concrete must meet the requirements of EM 1110-2-2000, (Standard Practice for Concrete, September 1982). Hydraulic design data indicates that some concrete will be subject to water velocities in excess of 40 fps. Superior quality concrete will be required in these areas and in the impact and stilling basins. Intermittent inundation of the concrete structures will occur, requiring special limitations on the water cement ratio.

b. Aggregate. - Ample quantities of suitable concrete aggregate are available from commercial sources in the vicinity of the project. Many of the aggregates in this area have a history of reactivity with the alkalies in



TYPICAL SECTION - SOIL CEMENT EMBANKMENT

FIGURE 2

cement. Alkali reactivity will be controlled by using low alkali cement ($NA_2O + 0.658K_2O \leq 0.6\%$), and type F, N or C Pozzolan with alkali content less than 1.5 percent. Local concrete aggregate producers are currently producing aggregates from the following locations.

(1) San Joaquin River. - Four major producers, all approximately 20 miles from the project site, are processing natural sand and gravel near the San Joaquin River. Past petrographic studies of aggregate from this source indicate that these materials may be classified as potentially reactive according to EM 1110-2-2000. These pits have been a source of concrete aggregates for the Fresno area for over 30 years. Two of the companies are producing crushed concrete aggregate, which improves strength and may reduce drying shrinkage of the concrete compared to rounded aggregate.

(2) Kings River. - One large producer is presently processing concrete aggregates from this source approximately 15 miles from the project site. Past petrographic studies have indicated that deleteriously reactive aggregates are present but are a minor constituent. This producer has been processing aggregates from this pit for over 25 years. Crushed concrete aggregate is available from this company.

(3) Kaweah River. - Two major producers are presently processing alluvial deposits for concrete aggregate from the banks of the Kaweah River, approximately 50 miles from the project site. Past petrographic studies performed on aggregates from this source indicate that little if any potentially reactive constituents are present. Aggregates from this source have been used to make concrete for over 30 years.

(4) Merced River. - Two companies are currently processing alluvial deposits from the Merced River, 12 miles north of the town of Merced. for concrete aggregate. This source is approximately 75 miles from the project site. Past petrographic studies on these aggregates indicate that it may be classified as potentially reactive according to EM 1110-2-2000. One operation has been producing concrete aggregates from this source for approximately 40 years, and the other has been in operation for about 3 years producing crushed concrete aggregate.

The most probable sources of aggregate for this project are the San Joaquin River and the Kings River, because of their proximity to the project site and the prevalence of these aggregates in local readymix concrete.

c. Cementitious Materials. - Numerous cement and pozzolan sources exist within a reasonable haul distance from the project site.

(1) Cement. - There are five presently active, and one inactive, cement plants located within 150 miles of the project site, and five more within 300 miles. All of these have demonstrated the ability to produce a type II, low alkali cement.

(2) Pozzolan. - Three types of pozzolans are available in the project area, but pozzolan is seldom used by local readymix concrete producers. Type N pozzolan is available from a source in northern

California. Type F pozzolan is being used by a few local readymix companies and is marketed by several distributors from sources in Washington, Wyoming and Arizona. Type C pozzolan is available from a source in Texas and another in Wyoming. As yet, these type C pozzolans have not been used in Federal construction. All three pozzolan types will inhibit detrimental alkali-aggregate reaction; however, type F and C provide the added advantage of improving the workability of the concrete mix, allowing for a reduction in water content and a corresponding increase in strength.

d. Admixtures. - Due to the relatively mild climate at the project site, air entrainment is not specifically required to prevent freeze-thaw deterioration. However, small amounts of air entrainment are necessary to provide workability to the concrete. Requiring the use of admixtures other than an air entraining agent is not advisable. Use of a water reducer and/or set retarder, when requested by the contractor, may provide some benefits to the government. Water reducing and/or set retarding admixtures may increase drying shrinkage of the concrete depending on the type and concentration used. Drying shrinkage tests should be conducted with any of these admixtures prior to allowing their use.

e. Water for Concrete. - Water suitable for curing and other miscellaneous concrete uses is available from local water districts. Water for mixing concrete will be provided as part of an existing readymix operation that will probably supply concrete to the project.

f. Readymix Concrete. - Local readymix concrete producers will be the likely source of concrete for this project, rather than an on-site concrete plant. Several readymix concrete suppliers are located within 15 miles of the project.

g. Laboratory Studies. - All four sources of concrete aggregate in the project vicinity have been tested by the South Pacific Division Laboratory and/or the Bureau of Reclamation Laboratory. Except for the Merced River source, which was last tested in 1980, the available test results from these laboratories are 15 to 30 years old and many of these results may not be indicative of the aggregates currently being processed from these sources. Current testing of aggregate sources will be completed soon and will be discussed in FDM 8 - Concrete Materials.

h. Service Performance Record Investigation. - Ample service record information is available for all four sources of concrete aggregate, because of the many Federal dam projects in proximity to the project site that were constructed with these aggregates.

47. Construction Materials. - Embankment designs for both Big Dry and Fancher Dams were based upon properties of local materials. Generally speaking, the economics afforded by short haul distances justify this procedure. However, it appears economically and technically feasible to use detention basin soils in construction of Big Dry Dam. Similarities between the different features' primary test results and compaction properties support this assumption. However, accurate correlations among sites are not possible until additional secondary testing has been completed. Therefore,

to allow for a more accurate evaluation, secondary testing will be conducted on detention basin soils. Results will be used to substantiate decisions made concerning economic alternatives. Until secondary testing is complete, site borrow is considered to be the most economical source available.

a. Big Dry Creek Dam. - Construction of Big Dry Creek Dam will require 1,417,100 CY of material. A materials distribution diagram is shown on Plate B41.

(1) Borrow Area. - The following materials will be obtained from the borrow areas shown on Plate B42.

(a) Random Fill. - Random fill will be obtained from older alluvial deposits in the reservoir area. This material is generally homogeneous and will provide essentially impervious fill with good strength properties.

(b) Filter Material. - Recent alluvium, deposited in the streambed of Big Dry Creek, will be used to meet filter material requirements for the drainage zones of the dam. This material, which contains only a few percent fines, meets filter requirements. Figure 3 shows graduation ranges of the filter material.

(2) Commercial Sources. - The following materials will be obtained from commercial sources.

(a) Drainage Fill. - Drainage Fill, obtained from a commercial source, will conform to ASTM C33 specifications for size 7 Coarse Concrete Aggregate. The material is highly pervious and meets filter criteria if used with the recent alluvial deposits found along Dry Creek.

(b) Stabilized Base. - Stabilized base will be required for crest road construction. Gradations of this material will conform to Gradation A of Army Corps of Engineers Specification Number CE GS-02241.

b. Fancher Creek Dam. - Construction of Fancher Creek Dam will require 2,222,800 CY of material. For materials distribution see Plate F27.

(1) Borrow Area - The following materials will be obtained from the areas delineated on Plate F6.

(a) Impervious Fill. - Impervious Fill will be selectively borrowed upon completion of the stripping operation. The intent of the operation is to isolate and use the fine grained deposits of the borrow area for core materials. This material, comprised of both residual and alluvial soil, ranges in depth from a few inches to greater than 30 feet. By selective borrowing, the impervious fill will have gradations within the range shown on Plate F19. This material typically contains low to medium plasticity fines, and when properly compacted will have low permeability and good strength properties.

(b) Random Fill. - Random fill will be borrowed from decomposed granite. This material ranges from surface outcrops to depths of 30 feet or more in the creek channels, Plates F8 thru F15. The gradation of this material is shown on Plate F19. Well compacted decomposed granite will provide high strength parameters.

(c) Slope Protection. - Slope Protection will be obtained from top soil stripped from the foundation of the dam. This material will resist erosion and also provide an excellent base for turf.

(d) Filter Material. - Filter material will be borrowed from Recent Alluvial Deposits along Big Dry Creek (See paragraph 45 a (1)). Close proximity of these deposits suggests commercial sources will not be required. This material is granular, and meets filter material requirements. For typical gradations see Figure 4.

(2) Commercial Sources. - The following materials will be obtained from commercial sources located on either the Kings or the San Joaquin Rivers.

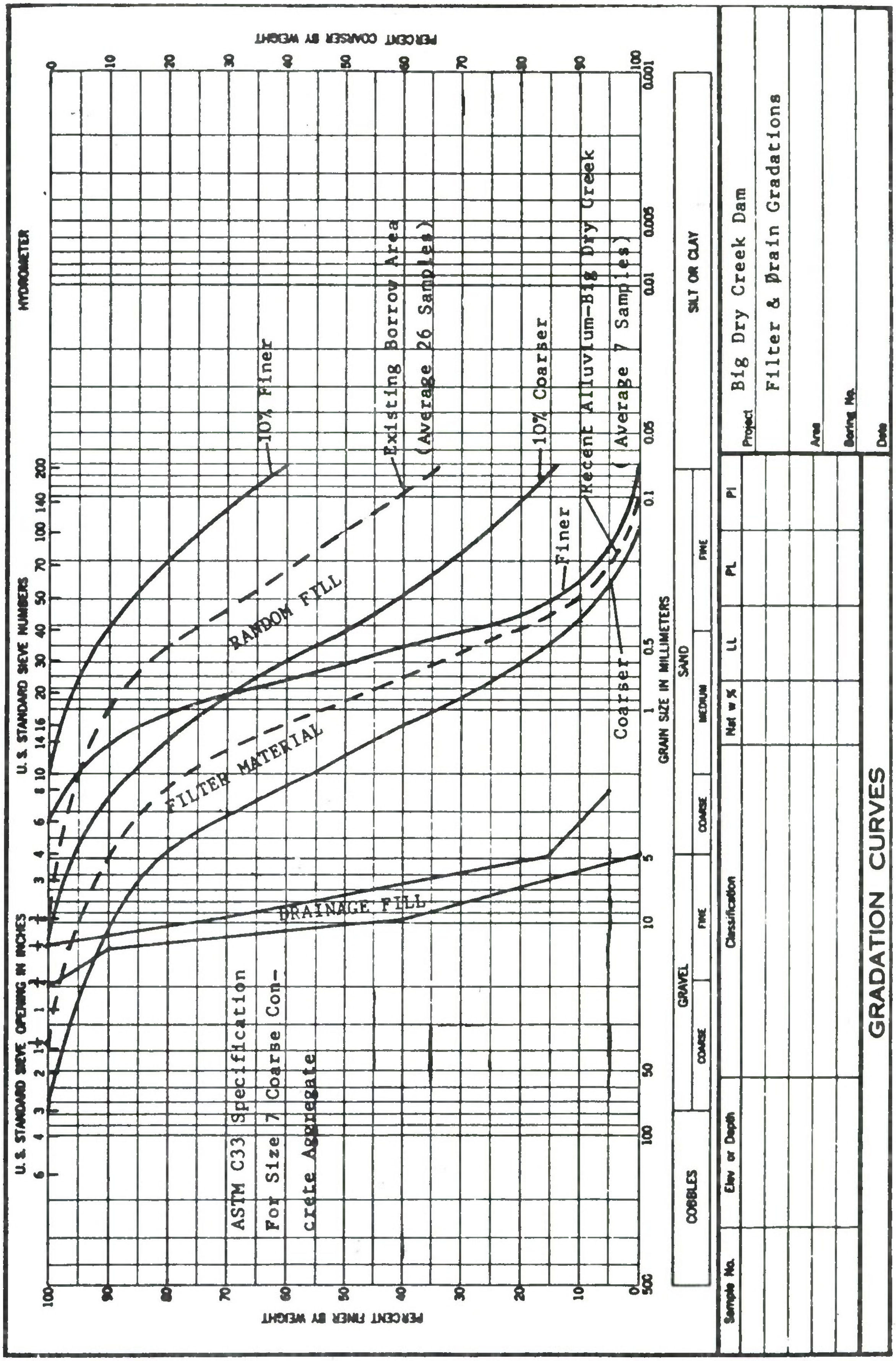
(a) Drainage Fill. - Drainage Fill will conform to ASTM C33 specifications for size 7 Coarse Concrete Aggregate. The selected gradation will provide a highly pervious layer that is compatible with the filter material borrowed from the Big Dry Creek site.

(b) Stabilized Base.- Stabilized base will be required for crest road construction. Gradations of this material will conform to Gradation A of Army Corps of Engineers Specification Number CE GS-02241.

c. Detention Basins.- All required embankment fill will be obtained on site.

d. Water For Construction. - Obtaining water for construction will be the responsibility of the construction contractor. Streams at the various sites typically dry up during the summer and will not provide a dependable source. Water may be available from the Fresno Irrigation District, particularly for the Alluvial Drain and Redbank Creek Detention basins from the Enterprise Canal and Mill Ditch, respectively. Water for Pup Creek Detention Basin is also available from the Enterprise Canal with about a half mile haul distance. Water also may be available from the Bureau of Reclamation from the Friant-Kern Canal for Fancher and Big Dry Creek Dam. Some water may be available from ground water. Water quality of the project area is discussed in Chapter V - Hydrology and Hydraulics.

e. Waste Areas. - The local sponsor is responsible for providing waste areas for disposal of waste materials resulting from construction of the project. Waste materials will consist principally of excavated soil material and concrete. FMFCD currently is identifying suitable waste areas. In addition, The County of Fresno has indicated that concrete and asphalt rubble could be disposed of in on-site landfills. If excavated material from Pup Creek and Alluvial Drain Detention Basins is used in Big Dry Creek Dam Embankment, the amount of waste material will be substantially reduced.



U. S. STANDARD SIEVE OPENING IN INCHES
U. S. STANDARD SIEVE NUMBERS
HYDROMETER
PERCENT COARSER BY WEIGHT
PERCENT FINER BY WEIGHT
GRAIN SIZE IN MILLIMETERS
COBBLES
GRAVEL
COARSE
FINE
SAND
COARSE
MEDIUM
FINE
SILT OR CLAY
10% Finer
Existing Borrow Area
(Average 26 Samples)
10% Coarser
Recent Alluvium-Big Dry Creek
(Average 7 Samples)
Finer
Coarser
RANDOM FILL
FILTER MATERIAL
DRAINAGE FILL
ASTM C33 Specification
For Size 7 Coarse Con-
crete Aggregate
Sample No.
Elev or Depth
Classification
Nat w %
LL
PL
PI
Project
Big Dry Creek Dam
Filter & Drain Gradations
Area
Boring No.
Date
GRADATION CURVES

FIGURE 3

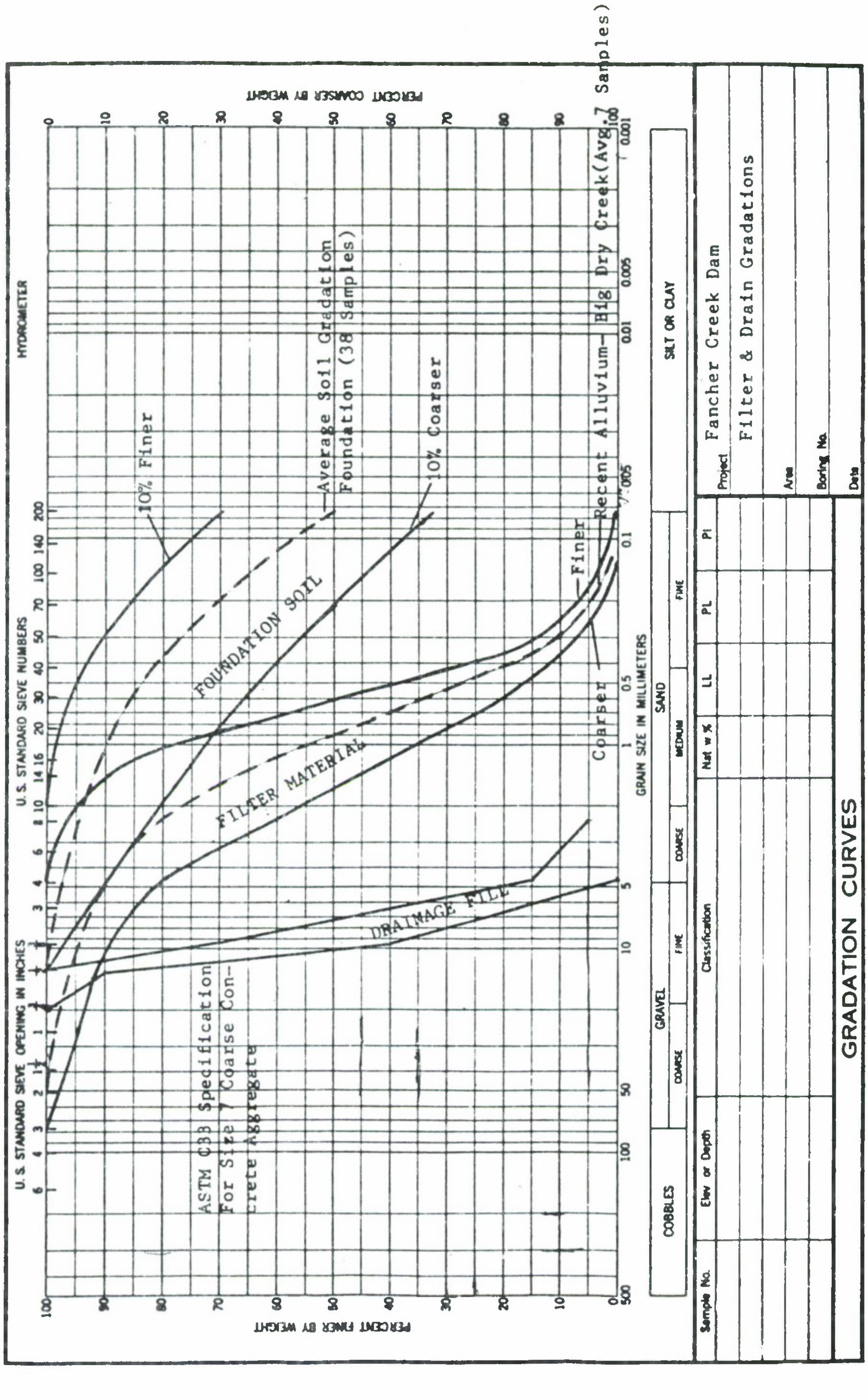

GRADATION CURVES
U.S. STANDARD SIEVE OPENING IN INCHES
U.S. STANDARD SIEVE NUMBERS
HYDROMETER
PERCENT FINER BY WEIGHT
PERCENT COARSER BY WEIGHT
GRAIN SIZE IN MILLIMETERS
COBBLES
GRAVEL
COARSE
FINE
SAND
MEDIUM
SILT OR CLAY
10% Finer
Average Soil Gradation Foundation (38 Samples)
10% Coarser
Recent Alluvium—Big Dry Creek (Avg. 7 Samples)
Finer
Coarser
FOUNDATION SOIL
FILTER MATERIAL
DRAINAGE FILL
ASTM C33 Specification For Size 7 Coarse Concrete Aggregate
Sample No.
Elev or Depth
Classification
Nat w %
LL
PL
PI
Project
Fancher Creek Dam
Filter & Drain Gradations
Area
Boring No.
Date
ENG FORM 1 MAY 63 2087

FIGURE 4

47. Introduction. - The Final Environmental Impact Statement (FEIS) for this project was circulated to the public and reviewed by the Board of Engineers for Rivers and Harbors in July 1980 and filed with the Environmental Protection Agency (EPA) on 7 November 1980. In May 1981, the Chief of Engineers submitted his Report, including the FEIS, to the Secretary of the Army. In November 1983, the Assistant Secretary of the Army (ASA) (Civil Works) transmitted his report to Congress, which was published in House Document No. 98-147 dated 23 January 1984, and on 17 November 1983 the Record of Decision (ROD) was filed. The ROD reflects the plan recommended to Congress by the ASA, and described in detail in this GDM.

Since completion of the FEIS, minor design changes have taken place. The previous ASA, Mr. William R. Gianelli, recommended that the recreation pool at Big Dry Creek Reservoir not be included as a Federal cost sharing item. Reduction of the pool area at Redbank Creek Detention Basin, minor increases in Pup Creek and Alluvial Drain Detention Basin pool areas, and elimination of the recreation areas and pool at Big Dry Creek Reservoir resulted in a net reduction of the environmental impacts of the project and entirely eliminated the only impacts which justified mitigation in the FEIS. Therefore, mitigation will no longer be required for this project. This is concurred in by the U.S. Fish and Wildlife Service (FWS) and the California State Department of Fish and Game (DFG). All the environmental effects that will take place with the present plan (Selected Plan), which is reflected in the ROD, were fully evaluated in the FEIS and the Selected Plan has less impacts, therefore a supplement to the FEIS is not required. During Feature Design Memorandum studies any changes in the project will be coordinated with the concerned environmental agencies. The following environmental assessment update the FEIS.

48. Changes in Environmental Effects of the Project. - Section 5.01 of the FEIS lists the probable adverse unavoidable environmental effects of the project. By eliminating the recreation pool from the plan, some of the impacts that were predicted in the FEIS have been eliminated. The recreation pool at Big Dry Creek Reservoir would have permanently inundated 550 acres of grassland and 49 acres of riparian vegetation, the current estimate which is 14 acres greater than that reported in the FEIS. An additional 90 acres of grassland would have been converted to a recreation area. To mitigate for the loss of 49 acres of riparian habitat, 70 acres of grassland adjacent to the pool would have been planted with riparian species to create wildlife habitat. The recreation pool has been deleted from the plan. Therefore, none of these losses will take place and no mitigation is required. The changes in environmental effects of the project between the FEIS and the Selected Plan are shown in Table 25.

49. Environmental Assessment of Present Project Impacts. - The Selected Plan consists of constructing an impoundment structure on Fancher Creek and raising Big Dry Creek Dam, both to temporarily contain flood flows. The present plan has reduced considerably the scope of permanent impacts to the environment. The remaining impacts include temporary inundation of 168 acres of agricultural lands at the detention basins, 845 acres of grasslands at Fancher Creek Dam, and the temporary inundation of 2,148 acres of grasslands

at Big Dry Creek Dam. The total current environmental impacts are temporary indundation of 160 acres of agricultural lands and 2,993 acres of grasslands. Most of the lands at both impoundments are presently heavily grazed by livestock.

Table 25

Changes in Environmental Impacts
Between the FEIS and the Selected Plan

Feature	Type of Impact	FEIS (Acres)	Selected Plan (Acres)	Percent Change
Big Dry Creek Dam	grassland inundated permanently	550	0	-100
	grassland periodically inundated	2,065	2,148	+4.0
	grassland converted to riparian	70	0	-100
	grassland converted to recreation	90	0	-100
	riparian permanently inundated	49	0	-100
Fancher Creek	grassland periodically inundated	1,065	845	-20.7
Detention Basins	agricultural lands periodically inundated	325	168	-48.3
Total Grasslands Periodically Inundated		3,130	2,993	-4.4

50. Environmental Impact of No Action. - Without construction of the project, the potential for flooding of agricultural lands would continue to incur flood damage to structures and utility and transportation facilities.

Public services would continue to be temporarily disrupted during flood events. Local historic sites and monuments in the Fresno Clovis Metropolitan Area would continue to be subjected to flooding damages. There will be no impacts to native vegetation or wildlife if there is no project related construction. Use of areas at Big Dry and Fancher by livestock will be slightly reduced by small increased duration of flood storage. Local land use planning agencies have indicated that growth will continue in the flood plain with or without the project. Development will more likely be constrained by availability of municipal services and local ordances.

51. Coordination. - Since the completion of the FEIS, coordination has been ongoing with the FWS, DFG, U.S. Department of the Interior, The Fresno Metropolitian Flood Control District, the EPA, and interested individuals and organizations. Pertinent letters from the FWS and DFG are included in Appendix B along with the most recent Fish and Wildlife Coordination Act Report, dated 23 December 1985.

52. Endangered Species. - The Endangered Species Office has advised that the project will have no impact to any threatened or endangered species, as indicated by the letter reproduced in Appendix B.

53. Cultural Resources. - Executive Order 11593; Section 106 of the National Historic Preservation Act of 1966 (Public Law 89-664); ER-1105-2-50 and other Federal statutes and regulations require government agencies to take into account the effect of their undertakings on any cultural resources which are on or eligible for listing in the National Register of Historic Places.

Two cultural resources surveys of the project area have been completed for the project. The first was conducted in 1975 and identified four prehistoric sites, two in Big Dry Creek and two in Fancher Creek Reservoir. No sites were noted in the three detention basins.

In 1983, a second intensive survey was undertaken by the University of California, Los Angeles (UCLA) Institute of Archeology. The purpose of this investigation was to examine the present condition of those previously recorded sites, survey the remaining project lands, and conduct limited test excavation for National Register of Historic Places eligibility. As in 1975, no sites were encountered in the detention basins. One additional prehistoric and one additional historic site were recorded at Big Dry Creek Reservoir and two additional prehistoric sites at Fancher Creek Reservoir were recorded, bringing the total sites now known for the project to eight. Six of these sites are in the project area and all are considered by UCLA to be eligible for the National Register of Historic Places and will be so recommened by the Corps to the State Historic preservation Officer (SHPO) and Keeper of the Register. Five of the sites (FRE-632, FRE-633 on Fancher Creek, and FRE-1154, FRE-1155, and FRE-1829H on Big Dry Creek) will be impacted either by partial or total inundation or by construction (FRE-1829H). Impacts to the sixth (FRE-1691) can be avoided.

The results of the 1983 field study are being prepared in report form and will be submitted to the SHPO, the National Park Service Interagency Archeological Services, and interested professionals for review. After review of the draft report, coordination will commence with the SHPO and

Advisory Council on Historic Preservation (ACHP) to determine what effects the project will have on any National Register eligible properties and what measures can be taken to avoid, lessen or mitigate potential project impacts of those archeological sites which cannot feasibly be avoided, mitigation will probably consist of a data recovery program. For the historic structures (FRE-1829H), other measures, including measured drawings, removal and/or reconstruction may be considered. It is expected that mitigation will not exceed the one percent limitation, based on the preliminary mitigation currently being developed at UCLA. If the cost of mitigation, after consultation with the SHPO and ACHP, exceeds one percent, additional funding will be requested through Congress.

54. Introduction. - The real estate requirements for the project features are as follows:

Feature	Required Area (Acres)
Big Dry Creek Reservoir	2,842.0
Fancher Creek Reservoir	1,378.0
Pup Creek Detention Basin	67.3
Alluvial Drain Detention Basin	60.0
Redbank Creek Detention Basin	172.0
Dry Creek Crossing Modifications	13.3

Except for the Dry Creek Crossing of the Friant-Kern Canal modifications, control of these lands will be acquired through fee title acquisition or flowage easements. Additionally, borrow easements will be obtained for a portion of the flowage easement lands located in Big Dry and Fancher Creek reservoirs. Lands required for the Dry Creek Crossing modifications will be taken through a combination of flood protection levee easements, and temporary construction easements. The local sponsor, Fresno Metropolitan Flood Control District, is responsible for providing all lands, easements, rights-of-way, and utility and real estate relocations and alterations required for the project.

No mineral operations were found in any of the areas required for the project; therefore, no future claim for mineral values is anticipated.

55. Big Dry Creek Dam. - The majority of lands in the Big Dry Creek Dam and Reservoir area are large, mainly unimproved, parcels of pasture lands that are located directly east of the existing dam and directly north of Tollhouse Road. The existing dam essentially eliminates the potential for any future rural residential development between the dam embankment and the Friant-Kern Canal. Therefore, the highest and best use of the majority of the land is for large acreage agricultural uses, primarily grazing. There is presumed to be State of California flowage easements over a majority of the lands in the existing Big Dry Creek Reservoir. The estimated real estate requirements are shown on Plate B42. The project's 2,842.0 acres will be used as follows:

Use	Area (Acres)	Fee Title (Acres)	Easement (Acres)
Dam and Outlet Works	150	150	
Gross Pool	2,024		2,024
Spillway Design Flood Pool	555		555
Riparian Vegetation Preservation	49		49
Permanent Pool	64		64
Total	2,842	150	
Borrow Area 1/	500		500

1/ These lands are included in the Gross Pool area.

56. <u>Fancher Creek Dam</u>. - About one-half of the Fancher Reservoir area is composed of small agricultural parcels of about 20 acres. These lands are used for row crops and rural residential dwellings. The other half is composed of larger (100 to 300 acre) parcels of grazing lands. Additionally, an 80 acre vineyard is located within the reservoir area. There are limited improvements on the subject lands.

Since the reservoir area contains a sufficient number of vacant 20-acre parcels for development, the larger grazing parcels are in no danger of being split into small parcels until the current 20-acre parcels are improved and additional areas closer to the cities of Fresno and Clovis are developed. Therefore, the highest and best use in the Fancher Creek Reservoir area is its present use of one-half the area for 20-acre agricultural parcels and the other half for larger parcel grazing lands. The estimated real estate requirements are shown on Plate F28. The project's 1,378.0 acres will be used as follows:

Use	Area (Acres)	Fee Title (Acres)	Easement (Acres)
Dam and Overchute	127	127	
Gross Pool	845		845
Spillway Design Flood Pool	406		406
Total	1,378		
Borrow Area 1/	275		275

1/ These lands are included in the Gross Pool and Spillway Design Flood Pool areas.

57. <u>Pup Creek Detention Basin</u>. - The Pup Creek Detention Basin area is composed of rural residential parcels, small agricultural properties and "open space" zoned (O-zone) lands. The 64.1 acres of land required for the basin itself are zoned for open space. They have a highest and best use of agricultural open space due to their low elevation and zoning. The 1.1 acres of land to be used for the open exit channel, and the 1.1 acres for the buried pipeline, are near new single family subdivision lands and therefore share the same highest and best use. A one year temporary construction easement on 1.9 acres is required to construct the piped exit channel. The open space zoned lands for Pup Creek Detention Basin are shown on Plate P1.

58. <u>Alluvial Drain Detention Basin</u>. - Currently, two types of land use are found at the Alluvial Drain Detention Basin Site. One section of 57 acres is zoned "open space" and has limited improvements. This area is required for the basin. The lands required for the exit channel are zoned and used for rural residential parcels. Three acres of land are required for the exit channel. The 57 acres required for the basin have a highest and best use of agricultural open space without homesites due to its zoning and the low elevation of the site. The rest of the area, mainly on the west side, for the channel and outlet works, has a highest and best use of rural residential. The open space zoned lands for Alluvial Drain Detention Basin are shown on Plate A1.

Real Estate Requirements

59. Redbank Creek Detention Basin. - The 172 acres required for Redbank Creek Detention Basin is made up of 144 acres of open space zoned lands and 28 acres of small agricultural parcels. The area's highest and best use is for small agricultural parcels. This usage applies to the open space zoned lands since higher elevations allows a more valuable use than open space, as compared to the lower elevation lands found at the Pup Creek and Alluvial Drain Detention Basin sites. The open space zoned lands for Redbank Creek Detention Basin are shown on Plate R2.

60. Dry Creek Crossing Modification. - The 13.3 acres required for the proposed modification of the Dry Creek Crossing of the Friant-Kern Canal and appurtenant embankments are being used for grazing. The highest and best use of lands required for the modifications is for livestock grazing. A Flood Protection Levee Easement shall be acquired for the two proposed new embankments and the additional lands required for the enlargement of the existing embankments.

Because the lands required for raising the existing embankments will be taken out of the potential grazing area, the value of the easement will be set equal to 90 percent of the fee value of the property. Considering the rolling nature of the surrounding land, the height of the two small new embankments should not prohibit the movement of grazing livestock. Therefore, severance damages cannot be justified here. A temporary construction easement for one year will be required for constructing the new embankments and raising the existing embankments. The real estate requirements for the modifications are shown on Plate B42.

61. Rights to Be Appraised. - The types of estates to be appraised are fee borrow easement, flowage easement (occasional flood) and temporary work easement. The measure of the value of the easement or fee estate to be acquired is the degree to which it encumbers or limits the use of the affected property. Fee estates will be estimated at full cash value. The majority of the lands to be taken in fee are to be used for the embankments and control structures. In addition, the landlocked property located between the Friant-Kern Canal and the Fancher Creek Dam will be acquired in Fee.

All other project lands except the residual pool at Big Dry Creek Dam are to be acquired by Flowage Easement (Occasional Flooding). The majority of these lands fall in the gross pool, spillway design flood pool, and the detention basin areas of the five project features.

62. Guide Taking and Project Boundary Lines. - The real estate guidetaking line will be determined in accordance with EP 405-1-2 and the 1966 joint policies established by the Department of the Interior and the Department of the Army. The guide taking line for each reservoir and detention basin will be the contour corresponding to the Reservoir Design Flood Pool plus an allowance for wave action. Because the guide taking line is based on a contour and set without regard to the effect of the fringe tracts of land, real property acquisition lines will be established following sound real estate practices with due consideration for the aspects of value of the remaining lands. Project operation and management, as authorized by law, will also be considered in establishing the project boundary.

Real Estate Requirements

63. Real Estate Relocations. - The proposed project will involve the application of Public Law 91-646 in the relocation of persons and personal property. Four houses, four turkey barns, and miscellaneous improvements will be affected. These costs are included in the lands acquisition cost estimates. The local sponsor will be responsible for real estate relocations.

64. Real Estate Requirement Costs. - The cost of lands, improvements, real estate relocations, damages, acquisition, and contingencies for the right-of-way requirements are summarized below and are presented in detail in the cost estimates in Chapter XV - Cost Estimates.

Feature	Costs ($)
Big Dry Creek Dam and Reservoir	1,798,136
Dry Creek Siphon Modification	1,864
Fancher Creek Dam and Reservoir	5,300,000
Pup Creek Detention Basin	700,000
Alluvial Drain Detention Basin	500,000
Redbank Creek Detention Basin	1,800,000
Total	10,100,000

These costs are based on the fair market value determined at the time the estimates were made. The estimates are based on October 1985 price levels.

Chapter IX - Relocations

65. Introduction. - The Redbank and Fancher Creeks, California project will affect roads, and power and telephone lines. The relocations will involve abandoning or moving the facilities to nearby locations just outside the impacted areas. The permanent environmental impacts of these actions will be minor. During construction, some specific impacts may be more severe, but these will be temporary and localized. The relocations will be paid for by the local sponsor. There are no relocations required for Redbank Creek Detention Basin and the Dry Creek Crossing of the Friant-Kern Canal. The relocation requirements are summarized in Table 26.

66. Roads. -

a. Big Dry Creek Reservoir. - The Behymer and DeWolf roads at Big Dry Creek Reservoir are owned by Fresno County. The roads serve agricultural grazing land and one turkey ranch which is to be removed in accordance with the reservoir clearing plan. The roads are old, in poor repair, barely wide enough to qualify as two lane roads and experience a very low traffic volume. Carson Road, which also crosses the Big Dry Creek Reservoir area, has recently been abandoned by Fresno County. The flood control operation of the existing Big Dry Creek Dam periodically inundates the roads with maximum possible depths reaching 30 feet. These roads will not be relocated because the reservoir operation for flood control will remain essentially the same as experienced with the existing project.

b. Fancher Creek Reservoir. - At Fancher Creek Reservoir, two access roads to private property will be severed by the dam embankment. These private roads will not be relocated per se; compensation will be provided to the property owners as part of the property acquisition procedure, Chapter VIII - Real Estate Requirements.

67. Utilities. - The utilities affected by the proposed project are power and telephone lines. There are no known gas distribution lines or other utilities at the project sites. All utility relocation work will be performed by the utility owners.

a. Power Lines. - Thirteen Pacific Gas and Electric Company power lines must be relocated or removed. These lines range from individual service lines for homes to 70 kV transmission lines. At Big Dry Creek Dam, 4,700 feet of 70kV transmission line with an attached 12kV line must be relocated. Each support tower consists of three timber poles. The line will be moved 50 feet south and parallel to the existing line. Also, approximately 6,600 feet of 12kV line at Big Dry Creek Reservoir will be abandoned. At Fancher Creek reservoir, two 12kV timber tower transmission lines totaling 3,300 feet will be relocated. In addition, 10,000 feet of 12kV transmission line will be abandoned. At the Alluvial Drain Detention Basin, 550 feet of 12kV transmission line will be abandoned. At Pup Creek Detention Basin, 1,950 feet of 12kV transmission line will be relocated by moving the poles short distances; approximately 50 feet on one line and across a road on another. A 2,875-foot section of 12kv line will be abandoned at Redbank Creek Detention Basin.

Relocations

Table 26

Relocation Requirements

Site	Power Length (feet)	Lines Capacity	Action 1/	Telephone Lines (feet)	Action 1/
Big Dry Creek Reservoir	4,700 6,600	70kV/12kV 12kV	r a		
Fancher Creek Reservoir	10,000 3,300	12kV 12kV	a r	3,000	c,a
Alluvial Drain Detention Basin	550	12kV	a		
Pup Creek Detention Basin	1,950	12kV	r		
Redbank Creek Detention Basin	2,875	12kV	a		

1/ c = construct new facility
r = relocate existing facility
a = abandon existing facility

b. Telephone Lines. - Both underground and aerial telephone lines are impacted by the project. Pacific Bell, owner of the lines, only has information on the major lines in the area. Individual lines serving residences were not considered. The relocation of these lines would be a minor expense that will be included in the relocation for overhead power lines serving residences, if any. At Fancher Creek Reservoir, approximately 3,000 feet of 25-pair copper cable must be relocated to the north end of the reservoir area. The existing cable will be abandoned in place.

68. Buildings. - Relocation assistance, described in Chapter VIII - Real Estate Requirements, will be required for the affected dwellings and associated buildings located at Big Dry and Fancher Creek Reservoirs. Relocation assistance will be provided by the project sponsor in accordance with PL 91-646.

69. Introduction. - The recommended clearing program was formulated and will be carried out in accordance with ER 415-2-1. Subsection (1)(a) of this regulation requires clearing from 0 to 3 feet above any permanent pool to 5 feet below the minimum pool. Clearing program objectives set out in paragraph 3 are to minimize health hazards, eliminate operational hazards, and benefit fish and wildlife. The regulations call for an evaluation of appearance, pollution, the environment, and the possible salvage value of any timber. Subsection (3) of the regulation does not require clearing if a permanent pool is not authorized. Reservoir clearing for the Redbank-Fancher Creeks project will follow these requirements. Reservoir clearing will be coordinated with state and Federal public health, fire protection, and wildlife agencies. Table 27 summarizes the reservoir clearing plan for each project feature.

Table 27

Reservoir Clearing Plan

Feature	Clearing Requirement
Big Dry Creek Reservoir	Remove house, 4 turkey barns, outbuildings, and associated facilities.
Fancher Creek Dam	Remove 3 houses and small vineyard
Alluvial Drain Detention Basin	None
Pup Creek Detention Basin	None
Redbank Creek Detention Basin	None

70. Big Dry Creek Reservoir. - The enlarged Big Dry Creek Reservoir will cover 2,767 acres at Spillway Design Flood (SDF) pool. This area consists of a 64 acre residual pool created by the existing project, 49 acres of riparian vegetation, 34 acres of orchard, with the balance in grazing land. A house, outbuildings, and 4 large barns on Behymer Road are located in the gross pool area. Clearing regulations require the house, outbuildings, and four barns to be removed. Although clearing the riparian vegetation and orchard would comply with the regulations, it would not meet the objective of effecting "maximum practical benefits to fish and wildlife within the scope of the authorization." Thus, the riparian vegetation and orchard in Big Dry Creek Reservoir will be retained. The riparian wildlife habitat has been developed over the past 37 years and provides for a wide variety of wildlife. It does not interfere with the current reservoir operation and is not expected to interfere with future construction, operation, or maintenance activities. By retaining the existing riparian wildlife habitat the need for mitigation and additional clearing costs are avoided.

Reservoir Clearing

71. Fancher Creek Reservoir. - Fancher Creek Dam lies east of and adjacent to the Friant-Kern Canal. The SDF pool area covers 1,354 acres, except for a small 80-acre vineyard, which is used mostly for cattle grazing and does not need to be cleared. Three houses are located within the gross pool area. Because regulations require structures to be removed from the gross pool area, the houses will be removed as part of the reservoir clearing plan. The vineyard will also be cleared.

72. Pup Creek Detention Basin. - The proposed Pup Creek Detention Basin covers 64 acres of open grassland. The area will be excavated 10 feet below grade. Consequently, everything will be cleared from the basin for excavation and no separate reservoir clearing will be needed.

73. Alluvial Drain Detention Basin. - The proposed Alluvial Drain Detention Basin area of 57 acres is open grass land with very few trees. The basin will be completely excavated to about 8 feet below grade. Consequently, everything will be cleared from the basin for excavation and no separate reservoir clearing will be needed.

74. Redbank Creek Detention Basin. - Redbank Creek Detention Basin, will cover 172 acres. An orchard covers 43 acres of the total area. The entire basin will be excavated 10 feet below grade. Consequently, everything will be cleared from the basin for excavation and no separate reservoir clearing will be needed.

75. Introduction. - The first project construction season is scheduled for FY-87 with execution of all required cultural resources mitigation work and modification of the Dry Creek crossing of the Friant-Kern Canal. Construction of the five main project features will be advertised under one contract and will begin in FY-88. The four project construction seasons and corresponding fiscal years are shown in Chapter XII - Schedules for Design and Construction. A Clean Water Act Section 404 evaluation of water quality impacts associated with project construction was presented in the Feasibility Report. The evaluation showed that since material will be placed in streams having flows of 5 cfs or less for more than 50 percent of the year, and there are no wetlands which will be affected, a full 404 evaluation is not required. These findings will be reviewed during preparation of plans and specifications.

76. Construction Access Roads. - Access for construction purposes to all five sites already exists. County roads can be used. They do not need to be improved because of the project. Access roads to the outlet works at Big Dry Creek Dam are already in place except for the service road which will be constructed along the dam crest. At Fancher Creek Dam a road will be constructed for construction and operation and maintenance of the outlet works. Approximately 6.0 miles of road will be needed to facilitate construction and subsequent inspection, operation, and maintenance of project facilities. The roads for the detention basins will be single lane, 12 feet wide, with 6 inches of stabilized aggregate base course (SABC) and no asphalt pavement. The road along Big Dry Creek Dam crest will be 16 feet wide, with 4 inches SABC, and the road to Fancher Creek Dam outlet works will be 20 feet wide, with 4 inches SABC.

77. First Project Construction Season. -

a. Dry Creek Crossing of the Friant-Kern Canal. - The work necessary to modify the Friant-Kern Canal at Dry Creek shall be initiated and completed during the summer months when precipitation and stream flows are minimal. A care and diversion of water plan is not required. The estimated required construction period is approximately four months. Plate B45 shows the sequence of the construction process described below. The modifications will be carried out during the first project construction season.

b. Cultural Resources. - Cultural resources mitigation work will be initiated and completed during the first project construction season. Mitigation plans currently are being finalized by the contractor (UCLA).

(1) Mobilization and Site Preparation. - The existing levee access roads shall be used while constructing the embankments and siphon headwall. Grade a smooth surface along the 10-foot wide crest of each of the two new embankments and along a 10-foot width on the reaches leading to and separating the dikes. This will provide access for inspection of the new embankments. Terminate the road in a turnaround. Establish centerlines and toes of embankments and limits of clearing.

(2) Stripping. - Strip all foundation surfaces for the proposed new embankments. For the existing embankments, strip to a depth of one-foot below the existing ground surface or as required for unique conditions if encountered. Waste stripped material.

(3) Embankment Placement. - Initiate and complete construction of new embankments to elevation 471.0. At the same time place embankment to elevation 471.0 on the existing Dry Creek embankment. Begin placing embankment at the point farthest from the siphon and work toward the siphon. Upon completion of the new embankment, place embankment to elevation 470.0 on the Friant-Kern Canal levee, also starting at the farthest point from the siphon.

(4) Siphon Headwall. - Concurrently with embankment construction, raise the Dry Creek siphon headwall to elevation 470.

(5) Dressing and Seeding. - Dress and seed all exposed surfaces.

78. Big Dry Creek Dam. - Construction of the Big Dry Creek Dam enlargement will begin in the second project construction season and be completed in two construction seasons. The construction sequence described below is shown on Plates B43 and B44.

a. Second Project Construction Season. - A plan view of the construction site after the second project construction season is shown on Plate B43.

(1) Mobilization and Site Preparation. - Establish the embankment, outlet works, and spillway centerlines; centerline stationing, and initial cross sections; and the limits of cutoff trench excavation, the spillway structure, the cofferdam abutments, and the borrow sites. In accordance with the clearing plan presented in Chapter X - Reservoir Clearing, perform necessary reservoir clearing. Strip and stockpile the top 6 inches of topsoil for redistribution (Plate B43 shows possible stockpile areas).

(2) Care and Diversion of Water. - All flows during construction of the new outlet works will be passed through the existing Big Dry Creek outlet. Construct cofferdam across the approach of the new Big Dry Creek outlet works, using random fill from the designated borrow area. Use a minimum crest elevation of 405.0, a 10-foot crest width, and 1V on 4H side slopes. Construction on both outlet works construction will be initiated and completed during the second construction season.

(3) Little Dry Creek Outlet Works Construction. -

(a) Existing Structure Removal. - Expose the entire Little Dry outlet works structure by removing the overlying existing embankment. Stockpile a sufficient amount of excavated material for subsequent backfill and waste excess. Remove the entire existing outlet works structure and riprap. Waste concrete and stockpile riprap for new stilling basin. Dress excavated area to minimize irregularities.

(b) Outlet Works Construction. - Backfill the excavated Little Dry Creek outlet works foundation area with lean mix concrete to elevation 400.0. Initiate construction of approach channel, tower, conduit, and stilling basin. Construct the base slab for the approach channel, control tower, conduit, and parabolic drop stilling basin. Construct the corresponding walls, placing water stops in the conduit and control tower joints up to elevation 443. Continue construction of the outlet works until the conduit and stilling basin are complete and the control tower is within one joint of the control house floor. Install the control gates and then complete control tower. Install the trash rack, gate operating mechanisms, and temporary power to the gates. Install temporary communications and operator access. Install flow gages. Test gates for full range of operations. Place riprap at downstream end of stilling basin. Reconstruct embankment at the outlet works from stockpiled and suitable borrow material.

(4) Big Dry Creek Outlet Works Construction. - Initiate outlet works construction by dewatering the work area.

(a) Outlet works Construction. - Excavate the existing embankment along the centerline of the new Big Dry Creek outlet works to elevation 397.0, Plate B43. Dress excavated area to minimize irregularities and compact subgrade. Initiate outlet works construction. Construct the base slab for the approach channel, control tower, conduit, and stilling basin. Construct the corresponding walls placing water stops in the conduit and control tower joints up to elevation 443. Continue constructing the outlet works until the conduit and stilling basin are complete and the control tower is within one joint of the control house floor. Install the control gates and then complete control tower. Install the trash rack, gate operating mechanisms and temporary communications and operator access. Test the gates and place riprap at downstream end of stilling basin.

(b) Existing Structure. - After construction of both new outlet works is complete, expose the existing Big Dry Creek outlet works inlet and exit structure by removing existing embankment. Remove and waste concrete in the existing Big Dry Creek approach walls, inlet weir, control tower, and stilling basin. Plug the existing conduit with concrete and reconstruct embankment to existing section. Reconstruct the embankment at the outlet works from stockpiled and suitable borrow material. Remove the coffer dam.

(5) Spillway Construction. -

(a) Existing Structure Removal. - Expose the existing spillway structure. Stockpile a sufficient amount of material for subsequent backfill and waste excess material. Remove the entire existing spillway structure and riprap. Waste concrete and stockpile riprap for new stilling basin. Dress excavated area to minimize irregularities.

(b) Spillway Construction. - Excavate for construction of approach walls, ogee section, stilling basin, exit walls, grade control sill, and riprap. Excavate the spillway approach and exit channels. Stockpile rock suitable for use as derrick stone or riprap. Waste remainder of material in designated waste areas. Compact subgrade in preparation for structures.

Initiate construction of the base slab for the exit channel, and stilling basin and the first lift of the ogee. Continue until ogee crest and all walls reach their full height. Construct grade control sill. Backfill around all spillway structures with suitable borrow, bringing ground line up to the preconstruction elevations. Place derrick stone and riprap downstream of spillway end sill.

(6) Embankment Foundation Preparation. - For the inspection trench, excavate and stockpile 160,000 cy of material located between Station 35+00 and Station 193+50 as shown on Plates B1, B17 and B43. Excavate from the upstream toe of the existing dam at 1V on 1.5H to elevation shown on Plate B1. Provide at least a 20 foot bottom width. Groom cut-off trench to remove irregularities and compact. Backfill cut-off trench with suitable material to the original ground line.

Excavate and stockpile existing embankment to foundation line between Stations 132+00 and 137+00 using a 1V on 2H cut slope. From existing foundation line, excavate and waste all the recent alluvium to elevation 377.0 as indicated on Plate B18 using 1V on 1.5H cut slopes. Dewater as necessary to complete excavation. After all recent alluvium is removed groom trench and compact. Backfill with suitable borrow and stockpiled material up to the existing dam crest.

(7) Relocations. - In accordance with the relocations requirements presented in Chapter IX - Relocations, execute necessary relocations.

b. Third Project Construction Season. - A plan view of the construction site after the third construction season is shown on Plate B44.

(1) Site Project Preparation. - Establish upstream and downstream toe of dam and clearing limits. Clear and strip the dam crest, sideslopes, and natural ground of vegetation and road material as required.

(2) Embankment Construction. - Construct the dam embankment. The upstream dam face slope shall be 1V on 3H to elevation 438.5. From elevation 438.5, the upstream slope will be 1V on 2H. The dam crest will be raised to elevation 442.6 with a crest width of 25 feet. A 16-foot wide access road consisting of 4 inches of SABC will be constructed along the dam crest. The downstream face slope will be 1V on 2.25H from toe to elevation 438.5 and then 1V on 2H up to the crest.

(3) Control Tower Bridge Construction. - When the embankment reaches elevation 434.6 ±, locate and construct the abutments for access bridges to the two control towers. Construct access bridges.

(4) Utilities. - Connect permanent power to control towers. Test the full range of gate operation. Connect permanent communications to tower and test. Install lighting, winch, doors, window guards, and all final accessories in both towers.

(5) Slope Protection. - Redistribute topsoil to a depth of 6 inches in borrow areas and areas stripped during construction. Place the slope protection material on upstream face from Fancher Creek Dam site. Place topsoil to a depth of 12-inches over downstream face of dam. Groom embankment slopes to remove irregularities and seed faces of dam, borrow areas and other areas stripped during construction with native grasses.

(6) Demobilization. - Repair county roads as necessary and groom project access roads.

79. Fancher Creek Dam. - Construction of Fancher Creek Dam will begin in the second project construction season and be completed in two construction seasons. The construction sequence described below is shown on Plate F29.

a. Second Project Construction Season. - A plan view of the construction site during the second project construction season is shown on Plate F29.

(1) Mobilization and Site Preparation. - Establish the embankment and spillway centerline, stationing, cross-sections; and the limits of the inspection trench and toe drain excavation, the spillway structure, and the borrow sites. Construct the required access roads. In accordance with the clearing plan presented in Chapter X - Reservoir Clearing, perform necessary reservoir clearing. Plate F29 shows possible stockpile areas.

(2) Care and Diversion of Water. - Construction will take place from April to October, during the period of minimal flow in Fancher and Hog Creek. Consequently, a diversion plan is not necessary. Diversion of the Friant-Kern Canal will not be required for spillway construction. The spillway site upstream of the existing Fancher Creek overchute will require dewatering. A system of pumps and a drainage trench will be used to drain the water into Hog Creek.

(3) Clearing and Stripping. - Clear 80 acres of vineyard and prepare the borrow area for excavation. Remove existing dikes and stockpile the material. Strip 24 inches from the dam foundation and stockpile for use as slope protection.

(4) Excavation. - Excavate inspection trench to specified elevations and stockpile material for the embankment. Strip at least 24 inches from the spillway foundation upstream of the Friant-Kern Canal and then excavate to specified elevations. Stockpile the material to be used as backfill. Remove the existing concrete wing-walls upstream of the Fancher Creek overchute. From dam Station 3+90 to Station 108+00, excavate for placement of the toe drain to specified elevations and stockpile the material for embankment fill. Strip and stockpile the top 6 inches of topsoil from the designated borrow area. Excavate the borrow area as necessary to keep pace with the backfill and embankment construction operation.

(5) Spillway Foundation. - Backfill the spillway foundation upstream of the Friant-Kern Canal with engineered fill, impervious fill, select fill, and drainage fill as specified. Remove the existing concrete bridge and

flip-bucket downstream of the Fancher Creek overchute. Excavate the stilling basin and exit channel area to specified elevations. Waste concrete and stockpile the excavated material for embankment fill.

(6) Toe Drain Construction. - Place filter cloth and 18-inch diameter slotted CMP pipe from Station 3+90 to Station 108+00. Jack the out-fall pipe under the existing Friant-Kern Canal at canal Station 1072+52. Backfill the toe drain with specified materials.

(7) Spillway and Outlet Works Construction. - Construct the base slab for the ogee crest, spillway channel, and parabolic drop and basin, tying the slab into the overchute. Construct the corresponding walls, placing water stops in all joints. Continue construction of the spillway channel and outlet works until the channel and stilling basin are completed. Place riprap as necessary.

(8) Inspection Trench Backfilling and Embankment Construction. - Backfill the inspection trench to specified elevations. Construct the embankment to elevation 474.5, the estimated flood water surface elevation with a 3-foot freeboard during the second construction season. Embankments at elevation 474.5 will be able to withstand a 25-year level of flood without overtopping. Training dikes are considered not necessary to protect the foundation areas without embankment because the ground is above the existing creekbeds. Place backfill at the parabolic drop and stilling basin walls up to existing ground elevations.

(9) Levee Road Construction. - Construct levee road with SABC to provide access across the new bridge located at the beginning of the parabolic drop structure.

(10) Embankment Protection Placement. - Provide turfed embankment protection on upstream and downstream slopes to protect the constructed portion of the embankment against erosion between construction seasons.

b. Third Project Construction Season. - A plan view of the construction site during the third project construction season is shown on Plate F29.

(1) Dewatering. - Repeat dewatering operation as necessary.

(2) Borrow Area Stripping and Excavation. - Strip and excavate the designated borrow area as necessary to keep pace with embankment construction.

(3) Embankment Construction. - Continue the embankment construction operation to bring the crest up to elevation 493.3 and place dam embankment from Station 83+00 to 98+00 and between Station 115+00 and 163+14. Backfill and compact around spillway walls during embankment placement.

(4) Construct conduit integrally with the ogee crest. Install the flow restrictor and trash rack. Place riprap as necessary. Install float well and recorder.

(5) Excess Material. - Spread the excess material from foundation stripping and excavation in the depression along the upstream edge of the designated impervious blanket area; grade to provide drainage away from the dam embankment.

(6) Borrow Area Gradation. - Grade borrow area to provide adequate drainage into Fancher and Hog creeks. Place stockpiled topsoil and seed borrow area.

(7) Dam Embankment Slopes Seeding. - Seed embankment slopes as specified.

(8) Service Road Construction. - Construct the 20-foot wide access road along the top of dam crest with SABC as specified.

(9) Demobilization. - Repair county roads as necessary and groom project access roads.

80. Pup Creek Detention Basin. - The work necessary to construct the Pup Creek Detention Basin, outlet works, and exit channel shall be performed and completed during one construction season. Precipitation and streamflows are practically nonexistent during the anticipated construction period; therefore, a care and diversion of water plan is not required. The estimated construction period is approximately seven months (April through October) and is divided into Phase I and II. Plate P9 shows the construction sequence.

a. Mobilization and Site Preparation. -

(1) Access Roads. - Use North Temperance Avenue and Locan Avenue for access during the construction season. The roads will not require modification.

(2) Clearing and Stripping. - Clear basin and channel area of loose trash and debris and remove from site. Strip all outlet works foundation surfaces and basin to a depth of 1 foot below the existing ground surface or as required for unique conditions, if encountered. Stockpile stripped material for later use.

b. Basin Excavation. - After clearing and stripping is nearly completed, begin excavating the southern portion of the basin and proceed north. Complete one-half of the basin excavation in Phase I of the construction season as shown on Plate P9. Basin excavation shall be completed in the Phase II construction period. The inlet area of the basin shall have 1V on 4H cut slopes. All other basin cut slopes shall be 1V on 8H. Form the basin invert to drain toward Pup Creek at a slope of 0.0001. Place and compact fill in designated area to elevation 373.8. Stockpile topsoil in designated areas for replacement later. All excavated soils shall be either wasted or stockpiled, as appropriate. Specific destinations and uses will be presented in the Feature Design Memorandum.

c. Outlet Works and Exit Channel Construction. - Excavate a channel with a 0.0003 slope from the upstream side of the outlet works to Temperance Avenue. The channel shall have a 10-foot bottom width, 1V on 2H side slopes.

A 12-foot wide road along the north bank of the channel shall be used as access during construction and for maintenance once the channel construction is completed. Cover the road with 6 inches SABC.

Once the outlet works area has been excavated, place all concrete required in the cradle for the 36-inch diameter reinforced concrete pipe conduit. Then, lay pipe and complete conduit work with formed concrete. Complete all formed concrete including intake structure, wing walls, and headwall at downstream end of outlet works. Place grouted riprap in scour hole. Backfill outlet works as needed.

d. Pipeline Construction. - The piped exit channel construction shall begin not later than 2 weeks after the outlet works/open channel construction has begun. Excavate the pipeline trench from the end of the City of Clovis' Pup Creek storm drain system to Temperance Avenue. Plate P9 shows the typical trench section. Concurrently, reroute traffic on Temperance Avenue and remove the two existing culverts at Temperance Avenue. After completion of trench excavation, place bedding material in and lay the single 48-inch diameter reinforced concrete pipe. Backfill trench to ground line. Perform all pipeline work moving from downstream to upstream. Construct a smooth transition between the open channel and the pipeline.

e. Embankment and Inlet Area Slope Protection. - After completion of outlet works, strip 1 foot below existing ground surface for foundation of retention embankment and downstream apron. Construct the combination soil cement and compacted soil retention embankment. The upstream portion will be compacted soil and the downstream portion and apron will be soil cement. Place soil cement slope protection along the 1V on 4H sloped inlet area. Place rock protection along the toe of the inlet slope.

f. Fencing. - Place 3-strand barb wire fence along the open outlet channel.

g. Dressing, and Seeding. - Replace stockpiled topsoil on all basin surfaces, then dress and seed all exposed surfaces.

h. Clean Up. - Repair county roads as necessary and groom project access roads. Remove construction equipment.

81. Alluvial Drain Detention Basin. - The work necessary to construct the Alluvial Drain Detention Basin, outlet works, and downstream exit channel improvement shall be performed and completed in one construction season (March-October). During this period, diversion of Alluvial Drain will not be a problem as precipitation is unlikely and streamflows are practically non-existent. The work requiring the breaching of the Enterprise Canal is scheduled to begin sequentially with exit channel and access road construction (August to October). Construction shall proceed in the manner and sequence set out below. For construction sequence plan and schedule see Plate A8.

a. Access Roads. - Existing roads (Temperance Avenue, Shepherd Avenue, Armstrong Avenue, Nees Avenue) are adequate for access and haul roads during construction.

b. Clearing and stripping. - Clear basin and exit channel area. Strip basin area to a minimum depth of 1 foot below the existing ground line and stockpile the topsoil in the designated area.

c. Basin Excavation. - Excavate the basin to 1 foot below the invert elevation and excavate the cut slopes at basin inlet as shown on Plate A1. Grade the basin invert to drain to the outlet works. Initiate excavation of the detention basin in the vicinity of the outlet works and proceed towards the basin inlet. Excavated soils shall be wasted, stockpiled, or used as random fill as appropriate.

d. Erosion Protection. - Place soil cement and riprap on cut slopes at the basin inlets.

e. Exit Channel and Access Road Construction. - Excavate the exit channel and construct the access road. Initiate excavation at the downstream end of the exit channel and proceed towards the outlet works. Remove and dispose of the existing culvert under Armstrong Avenue. Place new culvert and resurface the road to match the existing road. Detour traffic as necessary. Construct property fence around the exit channel and access road.

f. Outlet Works Construction. - Construction of the outlet works requires the breaching of the Enterprise Canal. A detailed diversion plan for the canal is presented in construction Sequence Plate A8 to insure that the Fresno Irrigation District can meet contractural committments to deliver irrigation water downstream. Divert the Enterprise Canal. Remove and dispose of Enterprise Canal lining as necessary to accommodate construction of the outlet works. Excavate and prepare the outlet works foundation. Initiate and complete concrete work. Backfill and prepare Enterprise Canal subgrade. Replace Enterprise Canal lining. Remove diversion channel. Place rock slope protection.

g. Dressing and seeding. - Redistribute stockpiled topsoil. Seed basin area with native grasses.

h. Demobilization. - Groom and repair access roads and bridges as necessary. Remove construction equipment.

82. Redbank Creek Detention Basin. - The Redbank Creek Detention Basin will be constructed in two construction seasons beginning in the second project construction season. The construction sequence described below is shown on Plate R2.

a. Second Project Construction Season. - A plan of the construction site during the second project construction season is shown on Plate R11.

(1) Mobilization and Site Preparation. - Establish proper boundaries, basin reference line, centerline of headworks, centerline of all embankment sections as well as horizontal and vertical control. Clear the north basin, new Mill Ditch alignment, and the alignment for the access roads. Strip the north basin, new Mill Ditch alignment, and the Redbank Creek diversion sites. Strip all foundation surfaces 1 foot below existing ground surface. Stockpile topsoil for later use.

(4) North Basin Excavation. - Excavate the basin north of existing Mill Ditch, using 1V on 8H cut slopes on the north and east perimeter. Preserve the existing Mill Ditch by starting the excavation 15 feet from the north edge of the ditch and cutting 1V on 2H side slopes to the north basin invert. Waste all excavated material.

(5) Mill Ditch Excavation. - Excavate rerouted Mill Ditch. Stop excavation within 100 feet of existing Mill Ditch on each end. Excavate cut slopes at 1V on 3H. Use a 12 foot bottom width and an invert slope of 0.0013. Waste all excavated material. Excavate for and place gabion slope protection on the outside of each bend.

(6) Redbank Creek Diversion. - At the end of the irrigation season, place cofferdams in Redbank Creek 150 feet upstream and downstream from the centerline of the control structure. Excavate a diversion channel around the control structure construction zone. Match inverts with the existing channel at both ends of the diversion. Place three 54-inch diameter culverts in the invert of the diversion channel and fill around the culverts to form a 25-foot wide access road to the control structure. Waste all excavated material. Drill and case four 40-foot deep wells, one 50 feet upstream and one 50 feet downstream of the control structure on each bank of Redbank Creek,for controlling groundwater during construction. Construct a 20-foot wide access road from the intersection of Clinton and North Locan Avenues to the north bank of Redbank Creek, terminating the road in a turnaround.

(7) Reroute Mill Ditch. - At the end of the irrigation season (September) excavate the final 100 feet of rerouted Mill Ditch at each end and place an earth plug in existing Mill Ditch downstream from DeWolf Avenue to direct all flows to the new channel. Excavate for and place slope protection on the outside of the bend. Complete excavation of the new Mill.

(8) North Soil Cement Embankment Construction. - Establish the boundaries for clearing the embankment area north of Redbank Creek. Clear and grub all trees, bushes and shrubs. Strip the top 1-foot of soil from the embankment foundation and waste. Excavate for placement of the soil cement capped embankment. Form the embankment section and downstream apron of compacted soil and soil cement.

b. Third Project Construction Season. - A plan of the construction site during the third construction season is shown on Plate R12.

(2) Ground Water Control. - Install four portable pumps in the construction area, providing for their outfall beyond the cofferdams. Dewater the control structure site, maintaining the groundwater table below elevation 320.0.

(3) Clearing and Stripping. - Reestablish the clearing limits and clear the South basin area. Strip the top 1 foot of soil from the cleared area and stockpile.

(4) South Basin Excavation. - Excavate the south basin, including the remaining section north of the existing Mill Ditch, to elevation 342.2. Use 1V on 8H cut slopes for all side slopes not intersecting Redbank Creek.

Waste all excess excavated material at designated sites. Slope the basin invert to drain toward Redbank Creek.

(5) Control Structure Construction. - When the groundwater table has been drawn down sufficiently in the area of the headworks, excavate for control structure placement to elevation 320. Stockpile native material for backfill. Recompact foundation, place engineered fill, and place base slabs and walls for structure. Backfill around structure. Fill void between headwalls and compact.

(6) Gate Installation. - Place gate bearings, braces and seals in prepared gate support structure. Adjust to assure proper alignment and location. Permanently grout bearings, braces and seals. Place gate operating mechanism into position and bolt to bearings and braces as required. To allow for ballasting, seal the float chamber and fill with water to elevation 338.5 as shown on Plate R2. Place steel shot in the float and ballast tanks as required to achieve proper gate operation. Remove the seals from the float chamber to prepare the gate for normal operation.

(7) South Soil Cement Embankment Construction. - Clear and grub all lands to be occupied by soil cement embankments. Remove and stockpile 12 inches of topsoil for redistribution after construction. Excavate 2 feet below existing ground for placement of downstream slab. Place and compact a 6 inch lift of soil adjacent to the location of the soil cement slab. With compacted soil in position, place and compact a 6 inch layer of soil cement against the previously placed soil. Continue the placement of soil cement lifts to achieve the configuration indicated in the plan. Trim excess soil cement to obtain smooth slopes. Place compact and trim upstream soil surfaces, including topsoil, to obtain a smooth transition from top of basin cut or from existing ground. Seed all exposed soil surfaces. Remove cofferdams and modify creek invert as required. Remove diversion channel culverts and fill and compact diversion channel. Once the diversion channel is backfilled, construct soil cement capped embankment number 1, south of the headworks.

(8) Dressing and Seeding. - Redistribute the previously stockpiled topsoil on the sideslopes and basin invert. Slope basin invert to drain toward Redbank Creek. Use a minimum slope of 0.0001. Seed area with native grass for erosion protection.

Chapter XII - Schedules for Design and Construction

83. Introduction. - The project has been planned so that Design Memorandums (DM) and detailed contract plans and specifications can be prepared separately according to the major project features, as shown on Plate G8. The work has been divided in this manner in order to permit an orderly, timely and efficient sequence of design leading to construction. The schedule is based on the assumption that Congressional authorization and construction funding will be provided by FY-87.

84. Design Memorandum Schedule. - Seven Design Memorandums will be prepared for the project during FY-86, allowing for a new construction start in FY-87. A Feature Design Memorandum (FDM) will be prepared for Big Dry Creek Dam and the Dry Creek Crossing of the Friant-Kern Canal, Fancher Creek Dam, and the three detention basins. Three Geology DM's will be prepared during FY-85 and FY-86, corresponding to the three FDM's. In addition, a concrete materials DM will be prepared for the project. Plate G8 shows the DM preparation schedule.

85. Plans and Specifications Schedule. - A comprehensive set of plans and specifications will be prepared during FY-87, based on the three FDM's. However, a separate set of plans and specifications for the required modification of the Dry Creek Crossing of the Friant-Kern Canal will be prepared to allow for construction initiation of this element at the earliest possible date. In addition, plans and specifications for cultural resources mitigation work will be developed early in FY-87. Plate G8 shows the plans and specifications preparation schedule.

86. Construction Schedule. - The first project construction season will begin as soon as local cooperation and cost sharing agreements with the local sponsor, Fresno Metropolitan Flood Control District, are finalized. During the first project construction season, the cultural resources mitigation work and Dry Creek Crossing of the Friant-Kern Canal modifications will be initiated and completed. Construction of the five main project features will be advertised under one contract to allow for efficient utilization of materials, equipment, and manpower. Big Dry Creek Dam, Fancher Creek Dam, and Redbank Creek Detention Basin will each require two full construction seasons. Pup Creek and Alluvial Drain detention basins will require one full construction season. Construction of the five features will begin during the second project construction season. Plates G8, B43, B44, F29, P9, A8, and R12 show the schedules for construction and construction sequences.

The estimate of funds required is based on October 1985 price levels and does not reflect the effects of inflation. The funds required include the Federal cost of the CP&E effort subsequent to FY-85, preparing plans and specifications, and constructing the project, and non-Federal cost of lands, easements, rights-of-way, relocations and alterations and required cash contributions. Cost apportionment between Federal and non-Federal interests is discussed in Chapter XVII - Cost Sharing and Local Cooperation Requirements.

Schedules for Design and Construction

The total project funds required for an efficient and continuous construction sequence are shown on Plate G8 and are as follows:

FY	Activity	Funds Required ($)
86	CP&E	700,000
	Construction	
87	First Season	4,480,000
88	Second Season	24,700,000
89	Third Season	24,000,000
90	Fourth Season	6,220,000
	Total	60,100,000

87. Introduction. - The five features of the Redbank and Fancher Creeks project will be incorporated into the comprehensive flood control system for the Fresno-Clovis Metropolitan area. The Fresno Metropolitan Flood Control District (FMFCD), the local sponsor, will operate the system. The overall operational objective of the Redbank and Fancher Creeks project is to control the major portion of flood waters presently flowing into the Fresno-Clovis area and allow the disposal of local flow below the project features at nondamaging rates through the Little Dry Creek Diversion channel and the Herndon Canal, to the San Joaquin River. Operation of the flood control system during project design floods will maintain a sustained flow of 200 cfs or less in Mill Ditch at the Temperance Avenue operating point, with a transient peak flow of 280 cfs. This limit on project controlled flow will allow the disposal of local flow and pumped urban flood waters at Temperance Avenue, at a short term rate of 350 cfs and a sustained rate of 300 cfs, into Mill Ditch, downstream from Temperance Avenue, and eventually into the Herndon Canal.

88. Measures To Be Taken When Significant Runoff Is Expected. - During the flood season, ground wetness and precipitation must be monitored. A cumulative precipitation parameter will be computed daily to indicate ground wetness. It will be computed by multiplying the previous day's parameter by 0.97 and adding the average of the daily precipitation recorded at Big Dry Creek Reservoir and Fancher Creek Reservoir. When the cumulative precipitation parameter is 5 inches or more and 0.3 inches or more of precipitation has occurred in the last three hours at Big Dry Creek or Fancher Creek reservoir, "significant" runoff can be expected and the following measures will be taken:

a. The diversion works at the confluence of Mill Ditch and Dry Creek must be configured to prevent sustained flows greater than 500 cfs and short term flows greater than 550 cfs in Herndon Canal downstream from Dry Creek.

b. Both outlet works gates in Redbank Dam must be fully open to insure structural safety of the dam and efficient operation of Redbank Creek Detention Basin.

c. The headworks on the Fresno and Gould canals must be configured to prevent Kings River water, above those flows necessary to meet irrigation demand, from entering the system.

89. Big Dry Creek Reservoir. - Big Dry Creek Reservoir will be operated for flood control. The total storage capacity at gross pool will be 31,785 acre-feet at elevation 433.2, 30,665 acre-feet for flood control and 1,120 acre-feet for sediment storage. Local interests requested that the capability to make releases to both Dry Creek and Little Dry Creek Diversion channels be maintained. Thus, the new Big Dry Creek outlet works will have a release capacity of 150 cfs at pool elevation 415, and the new outlet to the Little Dry Creek Diversion channel will be capable of releasing 700 cfs at elevation 416.4.

System Operation

Encroachments in flood control space (elevation 400 to elevation 439.6) will be released as rapidly as possible without causing damage downstream. If possible, minor flood releases will be made through the Dog Creek and Big Dry Creek outlet works to satisfy beneficial downstream demands. However, during large floods, these two outlets will normally be closed to allow the downstream channels to be used to pass local flow and all flood releases will be made through the outlet to the Little Dry Creek Diversion channel. The rate of change in releases to the Little Dry Creek Diversion channel will not be more than 200 cfs per hour, as currently specified for operating the existing structure. Flood releases through the Dog Creek and Big Dry Creek outlet works are not necessary to control the reservoir design flood (the Standard Project Flood). Except when the Little Dry Creek outlet works is being operated for flood control or maintenance and inspection reasons, the gates are to be kept in a raised, fully open position.

During large floods, the flow in Little Dry Creek Diversion channel must be monitored closely to assure that no spills occur through the existing wasteway in the Little Dry Creek Diversion levee. During periods of heavy precipitation, it will be necessary to monitor the flow at the wasteway gage continuously to assure that the combination of releases and local flow into the diversion channel does not exceed 700 cfs.

Normally, the gate changes at the Big Dry Creek Dam are expected to be controlled and monitored remotely from the FMFCD operation center. During significant events, when releases to the Little Dry Creek Diversion channel are being made and precipitation is forecast or actually occurring, the releases to the diversion channel are recommended to be controlled from the gate tower. Should the remote read-out from the wasteway gage fail, a visual inspection of the wasteway is mandatory since the wasteway will not be visible from either Big or Little Dry outlet works control towers.

90. Fancher Creek Dam. - Fancher Creek Dam will be ungated and requires no operation during floods. The outlet will be capable of releasing a maximum of 100 cfs at gross pool, elevation 480.5. The total storage capacity at gross pool will be 10,304 acre-feet, 9,908 acre-feet for flood control and 396 acre-feet for sediment storage. The feature will be capable of controlling all floods up to the 200-year event.

91. Pup Creek Detention Basin. - The Pup Creek Detention Basin will be ungated and requires no operation. The maximum release at gross pool, elevation 376.8, will be 25 cfs. The basin will be able to store 495 acre-feet of water.

92. Alluvial Drain Detention Basin. - The Alluvial Drain Detention Basin will be ungated and requires no operation. The maximum release at gross pool, elevation 386.4, will be 25 cfs. The basin will be able to store 385 acre-feet of water.

93. Redbank Creek Detention Basin. - Redbank Creek Detention Basin will have a gross pool of 940 acre-feet at elevation 349.3. It is designed to store all Redbank Creek flow greater than 200 cfs for all floods up to a 200-year

event, and to release the flood water from storage when basin inflow falls below 200 cfs. This operation will be controlled by a special gate system which will automatically facilitate the maintenance of a maximum release rate of 200 cfs from the Detention Basin to Mill Ditch.

94. Fancher Creek Headworks. - Flow at the Fancher Creek headworks must not be allowed to continue down Mill Ditch if it will cause flow at Temperance Avenue to exceed 200 cfs or interfere with the Redbank Creek Detention Basin operation.

95. Required Hydrologic Data Collection Equipment. - Hydrologic data collection equipment required for project operation, described in Chapter IV - Description of the Selected Plan, includes a pool gage in Big Dry Creek Reservoir, precipitation gages at Big Dry Creek and Fancher Creek reservoirs, stage gages in the Little Dry Creek Diversion channel immediately above the wasteway and just downstream of Little Dry Creek outlet works, and in Mill Ditch at Temperance Avenue. Except for the gage just downstream of the Little Dry Creek outlet works, all devices must be capable of being remotely interrogated from the FMFCD's operation center. Other hydrologic equipment provided with the project is for inspection and maintenance purposes and not directly required for project operation.

96. Operation Records. - The operating agency will be responsible for maintaining complete and accurate operation records for each feature of the Redbank and Fancher Creeks project. The complete operation record for each feature will be available to the Corps of Engineers upon request. Whenever the Big Dry Creek reservoir level is above elevation 403 the operating agency shall report to the Reservoir Control Section of the Sacramento District, Corps of Engineers, by telephone between 8:00 a.m. and 9:00 a.m. each work day and at other times upon request, the following data:

1. Reservoir stage and storage
2. Precipitation at the dam
3. Instantaneous flows at:
    a. Big Dry Creek at Academy
    b. Big Dry Creek below the outlet
    c. Dog Creek below the outlet
    d. Little Dry Creek Diversion channel below the outlet
    e. Little Dry Creek Diversion channel at the wasteway
    f. Spillway discharge
    g. Wasteway Discharge

Immediately after the end of each month, the operating agency shall dispatch to the Reservoir Control Section of the Corps of Engineers a summary for the month of the data outlined above. Monthly operation records for Fancher Creek Reservoir, Pup Creek, Alluvial Drain and Redbank Creek Detention Basins do not need to be dispatched.

97. Assumed Local Conditions For The Project Design Flood Routing. - The channel capacities and peak flows expected to occur during the project design flood and flow splits agreed to be controlled by FMFCD are shown on plate

System Operation

G7. The peak flows shown just downstream from the project features are a combination of maximum outflows and estimated local flows. For the Little Dry Creek Diversion channel, the Herndon Canal, and Fancher Creek the capacities are 700 cfs, 550 cfs, and 600 cfs, respectively. These design capacities were used as the basis for project design and will be required in the future in order for the project to provide the authorized degree of protection. The required channel capacities will be maintained by FMFCD over the life of the project. The following routing assumptions and necessary non-project operational requirements have been reviewed and concurred in by the FMFCD and are necessary to allow the total flood control system to function as designed.

a. Holland Creek. - Holland Creek flow would not enter the FID canal system during major floods.

b. Mud Creek. - All Mud Creek flow originating above and not passing under the Enterprise Canal was assumed to enter the Enterprise Canal up to its capacity, with the remainder flowing over the canal and continuing downstream. At the Gould Canal crossing, Mud Creek flows less than the Gould Canal capacity were assumed to enter the Gould Canal, with the remainder flowing overland to the Fresno Canal.

c. Enterprise Canal. - All water entering the Enterprise Canal, up to its capacity, south of Fancher Creek was assumed to enter Fancher Creek. All water entering the Enterprise Canal north of Fancher Creek was assumed to remain in the canal up to its capacity until reaching Dry Creek where all flows exceeding 90 cfs would spill into Dry Creek, the remaining 90 cfs continuing on to the Herndon Canal.

d. Gould Canal. - Water entering the Gould Canal south of Fancher Creek, in excess of 130 cfs, was diverted to the Fresno Canal through Vernon Ditch, up to 70 cfs; the remainder staying in the canal, up to its capacity, until reaching Redbank Creek. At Redbank Creek all flow exceeding 90 cfs was assumed to spill into Redbank Creek with 90 cfs continuing on to enter Dry Creek.

e. Fancher Creek Headworks. - Flow from the Fancher Creek headworks (Limbaugh) was allowed to continue down Mill Ditch as long as it did not cause the total flow at Temperance Avenue to exceed 200 cfs or interfere with the Redbank Creek Detention Basin operation. Otherwise the flow was diverted down Fancher Creek Canal.

f. Fancher Creek Detention Basin. - It is expected FMFCD will complete construction of Fancher Creek Detention Basin. This basin is not a project feature and will not be required for operation of the project as designed. It is designed to reduce flows in Fancher Creek Canal below the Fancher Creek headworks. If the basin is not constructed these flows will be expected to pass down Fancher Creek Canal.

g. Releases To Dry Creek. - Releases from Pup Creek and Alluvial Drain detention basins were assumed to flow into Dry Creek without impediments.

h. Sediment. - It was assumed that all space allotted to sediment storage was full at the start of the routing period for all project features.

i. Flows And Storages. - Flows and storages which resulted from the design flood routing are shown on Figures 5, 6 and 7 and on Plates B7, F3, P2, A2, and R3.

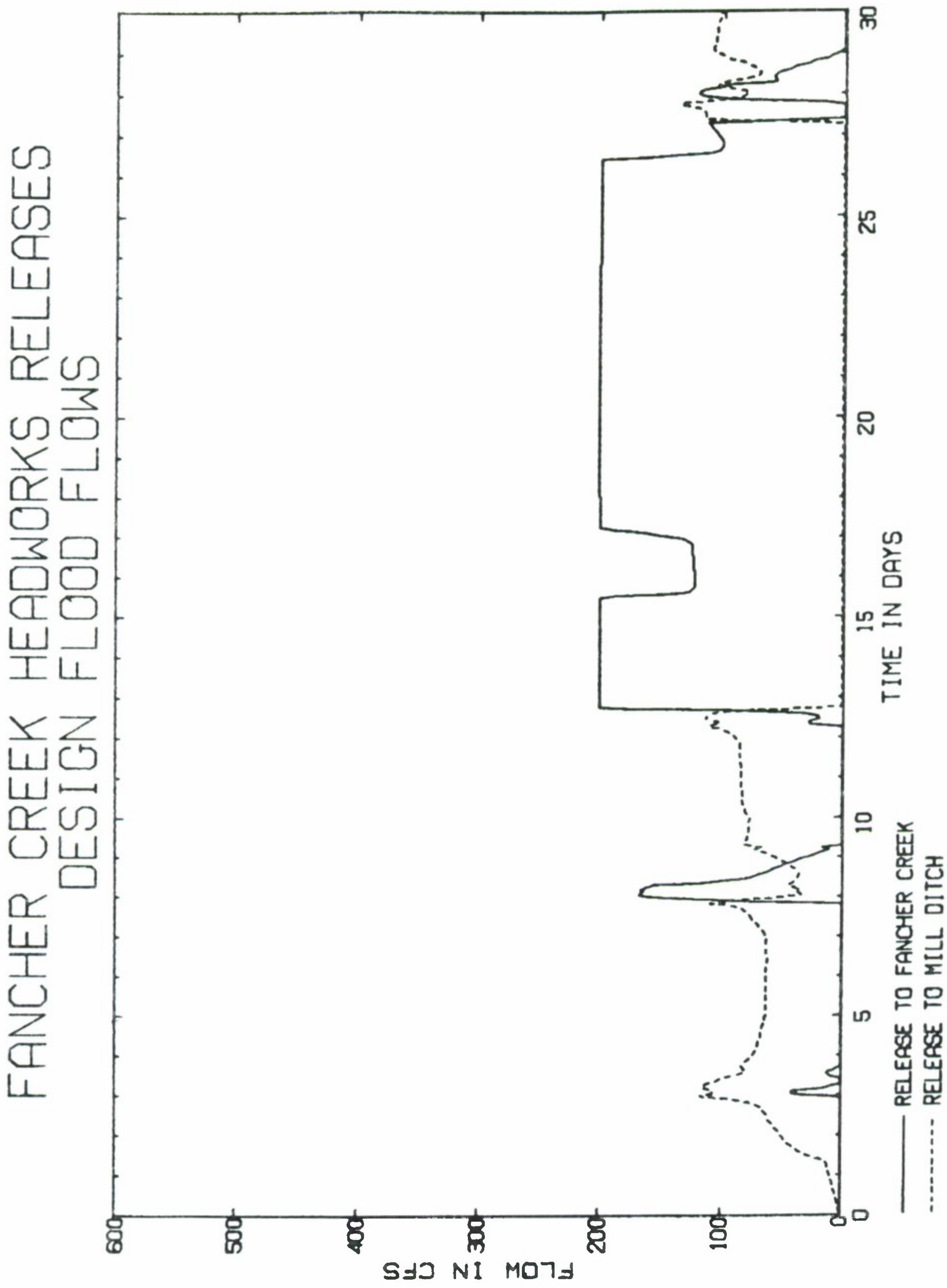

FANCHER CREEK HEADWORKS RELEASES
DESIGN FLOOD FLOWS
FLOW IN CFS
0
100
200
300
400
500
600
TIME IN DAYS
0
5
10
15
20
25
30
RELEASE TO FANCHER CREEK
RELEASE TO MILL DITCH

FIGURE 5

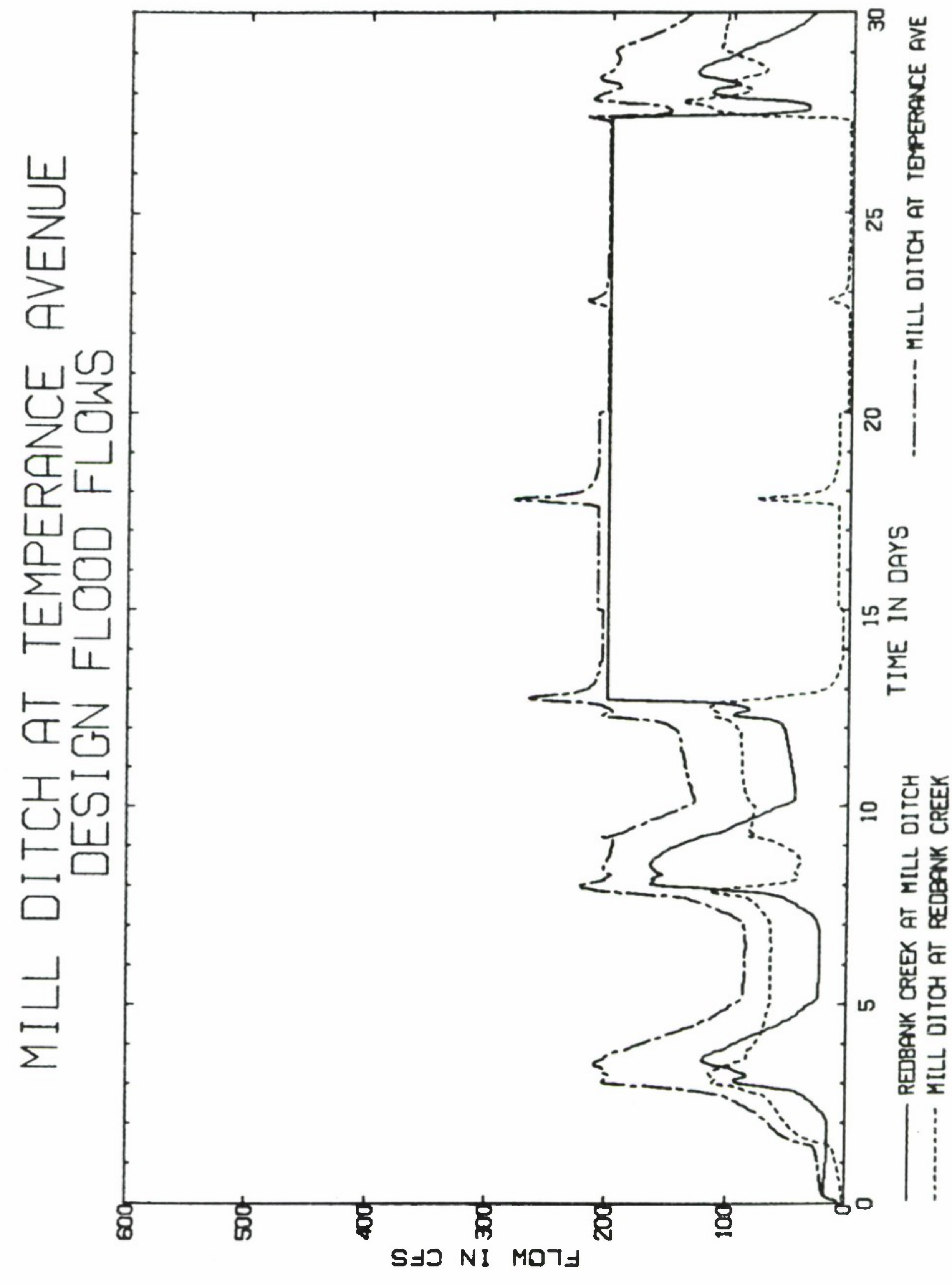
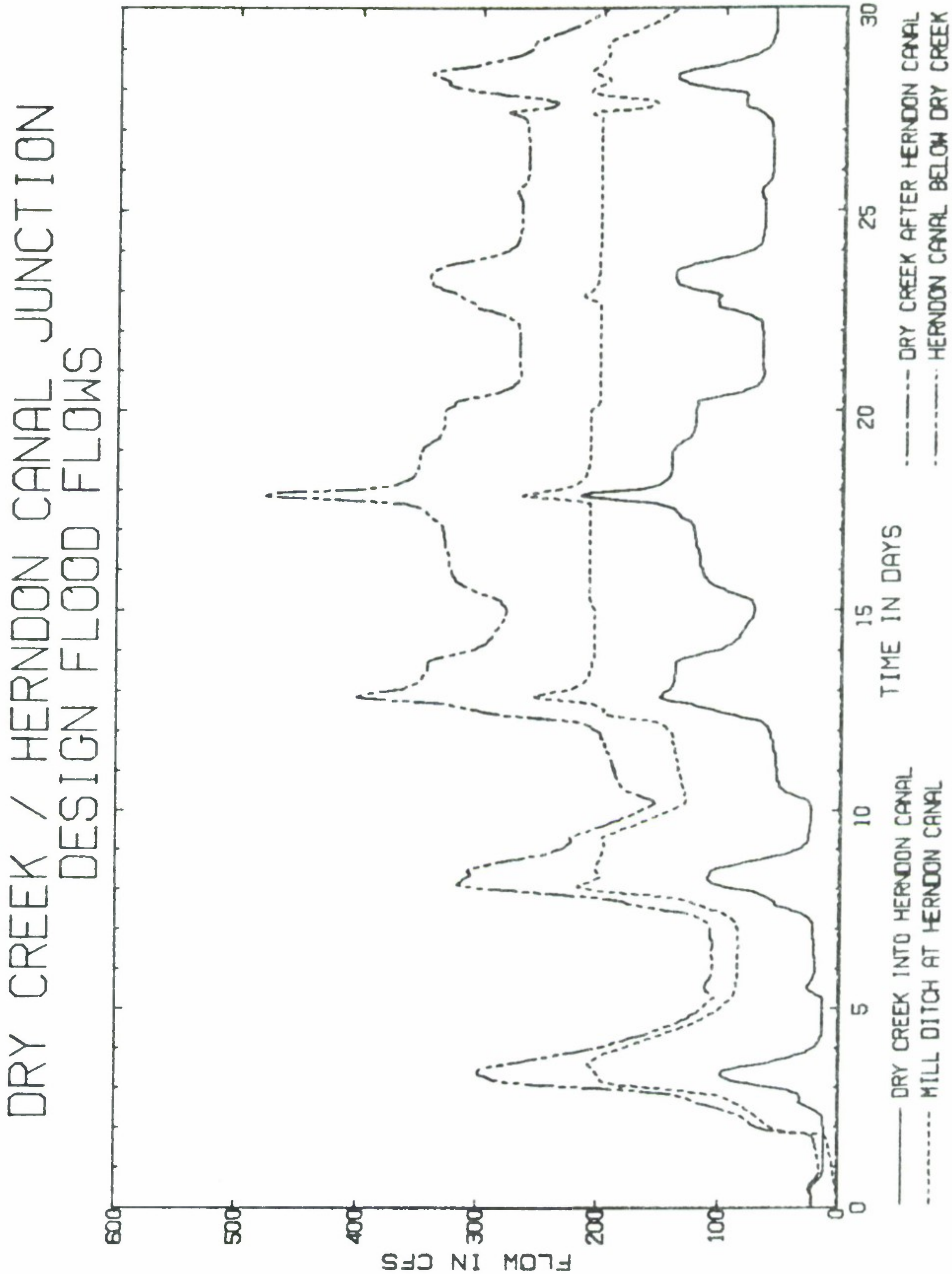

MILL DITCH AT TEMPERANCE AVENUE
DESIGN FLOOD FLOWS
FLOW IN CFS
0
100
200
300
400
500
600
TIME IN DAYS
0
5
10
15
20
25
30
REDBANK CREEK AT MILL DITCH
MILL DITCH AT REDBANK CREEK
MILL DITCH AT TEMPERANCE AVE

FIGURE 6



DRY CREEK / HERNDON CANAL JUNCTION
DESIGN FLOOD FLOWS
FLOW IN CFS
0
100
200
300
400
500
600
TIME IN DAYS
0
5
10
15
20
25
30
DRY CREEK INTO HERNDON CANAL
MILL DITCH AT HERNDON CANAL
DRY CREEK AFTER HERNDON CANAL
HERNDON CANAL BELOW DRY CREEK

FIGURE 7

Chapter XIV - Operation, Maintenance, and Inspection of Completed Work

98. Introduction. - The flood control facilities for the Redbank and Fancher Creeks project, described in Chapter IV - Description of the Selected Plan, will be operated and maintained by Fresno Metropolitan Flood Control District (FMFCD) in accordance with the general guidelines presented in the following paragraphs, and as described in detail in an operation and maintenance manual which will be developed before completion of the project.

99. Operation. - The Corps of Engineers will furnish instructions to FMFCD who will be responsible for flood control operations of the project. Normal flood control operations include daily monitoring of flows and reservoir stages, described in Chapter XIII - System Operation, to facilitate the appropriate manipulation of control gates. Permanent operating equipment is described in Chapter IV - Description of the Selected Plan. Fancher Creek Dam and Pup Creek and Alluvial Drain detention basins will be ungated and consequently will require no operation during floods.

a. Big Dry Creek Reservoir. -

(1) Gate Operation. - Mechanical features of the Big Dry and Little Dry Creek outlet works are shown on Plates B3 and B5, respectively. The flow of water through both outlet works will be controlled by electrically operated wedge lock type slide gates, located in the rectangular gate passages in the control towers. The electrically operated gate controller and appurtenances will be located in a chamber at the top of the control towers. Any gate leaf may be held in any desired position to permit the regulation of discharges. Control of each gate will be accomplished with a manually operated stop/start system. Each gate hoist will be provided with a mechanical type visual gate positioner indicator graduated in tenths and hundredths of feet. Further, the gate controls will be fitted with a remote operating system to allow for gate operation from FMFCD's operation center. The maximum hoist speed in raising and lowering the gate will be approximately 0.5 feet per minute. However, during flood control operations, the rate of change in releases to the Little Dry Creek Diversion Channel will not be more than 200 cfs per hour. Manual means also will be provided for controlling the movement of the gates. This feature will allow operation during power outages and fine adjustment of gate positions. The towers will provide the necessary penetrations for future installation of a telemetering system to report the gate position by radio to a remote operating site.

Two 3.0-foot square gates will be provided in tandem at Big Dry Creek outlet works. The upstream gate will act as an emergency gate and the downstream gate as a service gate. At Little Dry Creek outlet works, two sets of tandem gates will be provided. All four gates will be 3.0 wide and 6.5 feet high. Two will act as emergency gates and two as service gates. The emergency gate in each passage of the intake structure can be used to control outflow if a service gate is inoperable. Also, an emergency gate can be closed to allow emergency work on an inoperable service gate. The bifurcated intake structure was incorporated into the design of Little Dry Creek control tower to provide additional safety. In the event that one intake port is blocked, the other port can pass 80 percent of the design flow.

The Big Dry Creek outlet works gate will be closed during reservoir flood control operations.

(2) Power requirements. - The electric power extensions and transformer banks for the project will be supplied by the servicing utility company. Power requirements are estimated as follows:

Big Dry Creek Outlet Works

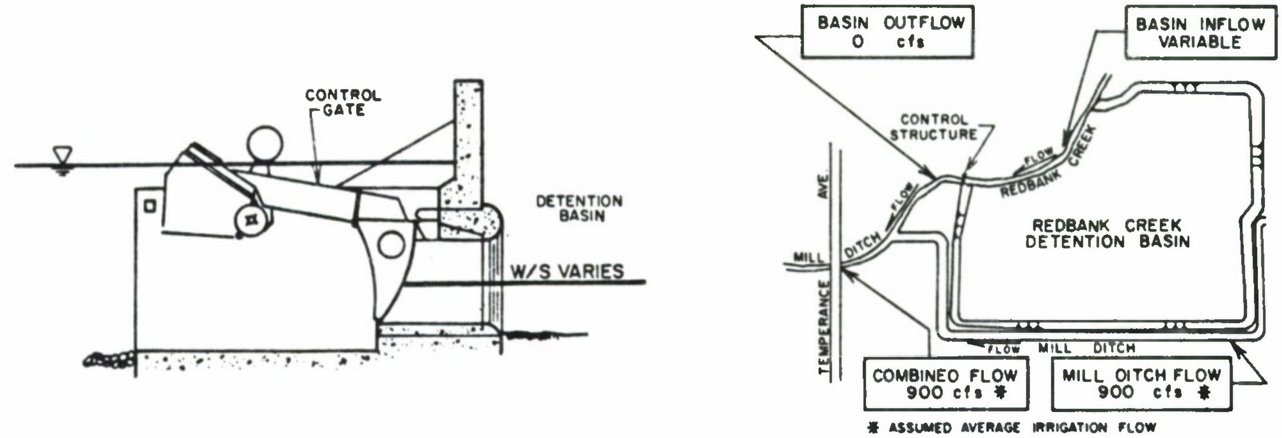
	Local Demand (Kilo Volt-Amp)
Sump pump motors, 1 hp 460V (future)	1.5
Lighting and miscellaneous power	5.0
Electrical Valve Actuators, 2 HP	5.0
Total estimated power demand at Control Shaft	11.5

Little Dry Creek Outlet Works

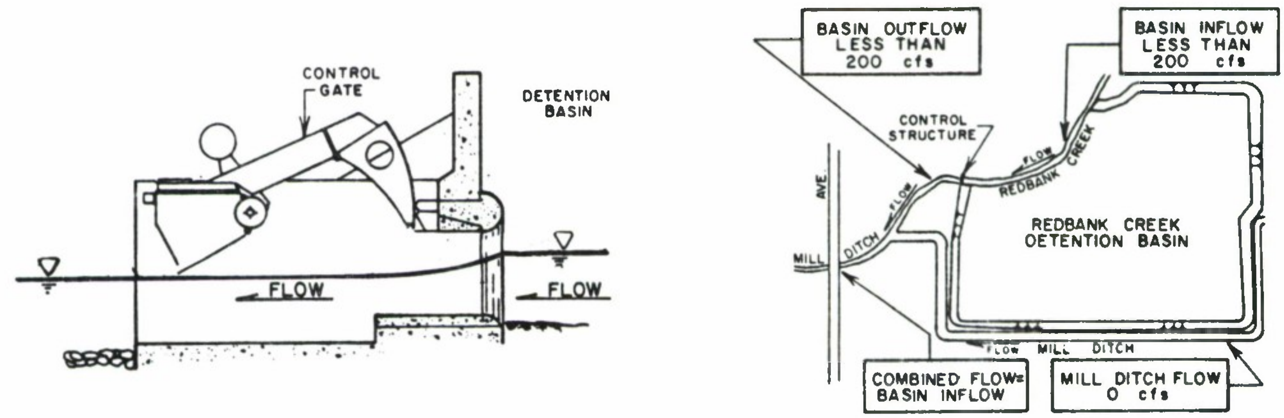
	Local Demand (Kilo Volt-Amp)
Sump pump motors, 1 hp 460V (future)	1.5
Lighting and miscellaneous power	5.0
Electrical Valve Actuators, 2 HP	10.0
Total estimated power demand at Control Shaft	16.5

b. Redbank Creek Detention Basin. - The mechanical features of the Redbank Creek Detention Basin outlet works are shown on Plate R2. The basin is designed so that water will be released through two orifices in the control structure. Flood control releases will be regulated by two automatic gates set in the control structure on the downstream side of the orifices. Gate operation is completely automatic and requires no electric power or manual manipulation. Each gate consists of a lever arm with a float chamber on the downstream end and a face plate on the upstream end and is designed so that the gate rotates in response to a change in tailwater elevation; as the tailwater rises, the gate face plate will descend behind the orifice, reducing the basin outflow. This reduction in orifice size causes a decrease in outflow which, in turn, drops the downstream water surface elevation, raising the gate. During this type of automatic operation, the downstream water surface will vary no more than +/- 0.1 feet, assuring a relatively constant release for a fluctuating upstream head. The gates will be set during their installation to maintain a downstream water surface elevation of 338.5 corresponding to a constant release of 200 cfs, the normal maximum allowable flow in Mill Ditch at the Temperance Avenue control point.

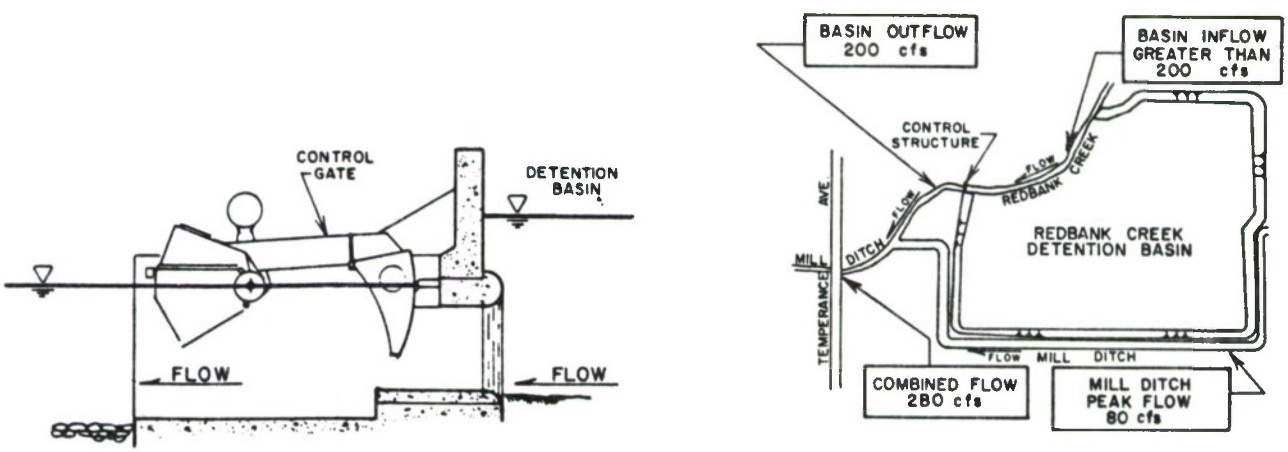
The gates are expected to have three distinctive modes of operation as shown schematically in Figure 8. Figure 8a shows the basin and gate configuration during irrigation season when Mill Ditch is flowing full. Backwater at the control structure from average irrigation flows in Mill Ditch of 900 cfs will be above elevation 338.6, the minimum elevation which



A. IRRIGATION SEASON (APR.-OCT.)



B. LOW FLOW



C. DESIGN FLOOD PEAK FLOW

FIGURE 8

causes the gates to close completely. When the gates are closed, all inflow to the basin is stored. This mode of operation is expected to occur from April through October. Figure 8b shows the basin and gate configuration expected between irrigation and flood season, when Mill Ditch flows and basin inflows are low and the water surface elevation just downstream of the control structure is below elevation 338.4. Under this condition the gates will be fully open, allowing free flow between the basin and Mill Ditch. Figure 8c shows the basin and gate configuration during the peak of the 200 year design flood. Basin inflow will be greater than 200 cfs and basin outflow will be regulated to 200 cfs. The only flow in Mill Ditch will be transient unregulated local runoff, estimated to peak at 80 cfs. The combined 200 cfs regulated release and peak 80 cfs local flow result in a short term peak flow of no more than 280 cfs in Mill Ditch at the Temperance Avenue control point, as indicated in Figure 6. If combined Mill Ditch flows and detention basin releases exceed 300 cfs, the resulting back water at the gates will reduce or completely shut off basin outflow.

100. Maintenance and Replacement. - Normal maintenance and required replacement associated with the dams, spillways, outlets works, channels, access roads, and hydrologic and communication facilities will be performed by the FMFCD in compliance with the Operation and Maintenance Manual to be prepared before completion of construction.

a. Maintenance of Embankments and Cut Slopes. - The provisions for embankment maintenance are spelled out in Paragraph (b) Levees, Section 208.10, Title 33 of the Code of Federal Regulations and any special instructions provided for this project. Measures are to be taken to promote the growth of sod on the earth embankments and cut slopes. All such embankment and cut slopes are to be kept mowed. The soil cement embankment sections for the detention basins are to be kept free of vegetation and other debris. These areas are to be inspected annually. Additionally, efforts will be required to prevent damage to embankments by burrowing rodents. The access and service roads are to be kept in usable condition at all times.

b. Maintenance of Exit Channels. - The FMFCD will be required to perform maintenance, operation, and inspection of all project exit channels in accordance with Section 208.10, Title 33 of the Code of Federal Regulations and any special instruction provided for this project. These regulations require regularly scheduled maintenance and inspection programs. All project channels, including rerouted Mill Ditch, must be maintained to their design grade, invert elevation, and capacity. Sediment is to be removed from the exit channels as required to maintain the design capacities. Local interests will be required to keep records of exit channel stream flows so that the effects of vegetation and other debris on channel capacity can be identified. Information regarding the functional capability of the project is to be reported annually.

Local interests will be responsible for maintaining riprap cobbles, and gabions placed as part of the project, and for providing any additional erosion control needed over the life of the project. Where riprap cobbles or gabions are placed as part of the project construction, it is to be kept free of vegetation and shall be inspected annually.

c. Detention Basins. - Sediment is to be removed from all detention basins periodically to maintain the design storage capacity and invert slopes.

d. Big Dry and Little Dry Creek Outlet Works. - At both Big Dry and Little Dry Creek outlet works, maintenance of either the emergency or service gates can be accomplished when the reservoir pool drops below elevation 400.0.

Access to the Little Dry Creek outlet works conduit for inspection purposes will be through the downstream portals. Access also could be from the upstream end when the reservoir pool is below elevation 403.0. Because of the small size of the Big Dry Creek outlet works conduit, a man hole will be provided between the service and emergency gates to allow direct access to the gate section. Access to the conduit can be had through the upstream portal when the reservoir pool is below elevation 400.0.

e. Redbank Creek Detention Basin. - Access to the gates for maintenance purposes will be afforded after the irrigation season when the flows in Mill Ditch are low and when the basin is dry. During all other times a visual inspection of the gates can be performed to determine their condition.

101. Miscellaneous Facilities. - Operation and maintenance of existing facilities in the Fresno-Clovis area used for flood control but not part of the proposed project will be required to meet the project purpose. These facilities must be maintained to the capacities indicated on Plate G7 for proper system operation, described in Chapter XII - System Operation and Appendix A. They include but are not limited to the Little Dry Creek diversion channel and wasteway and the Kings River diversion.

FMFCD also will be required to control encroachments in and along the project related streams and canals, keep records of flows and stages, and report on their functional capability annually. The design capacities shall be maintained by FMFCD to insure the proper functioning of the flood control project. The canals include the Enterprise, Gould, Fresno, Herndon Canal and Mill Ditch. The streams include all those directly affected by the proposed project such as Dog Creek, Dry Creek, Redbank Creek, Fancher Creek, Pup Creek, and Alluvial Drain as well as local streams indirectly affected such as Holland and Mud Creeks.

102. Periodic Inspection. - In accordance with Sec. 7, 58 Stat. 890, 33 USC 709, periodic inspections and reports shall be provided for each facility comprising the Redbank and Fancher Creeks, California project. The purpose of such inspections is to assure continuing structural adequacy of each dam, basin and associated structure. In addition, because the existing irrigation canals are a primary means of diverting surface flows during floods, annual project inspection will include the canals.

103. Basis of First Cost Estimate. - The estimate of first cost for the Selected Plan is summarized in Table 28. The cost is based on 1 October 1985 price levels, and prepared in accordance with guidance in SPK-EDM No. 46 and ER 11-2-240. The estimated cost of real estate is based on market value of lands as determined by the Real Estate Division of the Sacramento District from recent sales in the Fresno area. The unit prices used for construction are based on plant, labor, and material breakdowns and adjustment of average bid prices received on comparable work. The cost shown for cultural resources mitigation is based on the preliminary mitigation plan currently being developed at UCLA. A 15 percent contingency allowance was used for all of the construction items. A 35 percent contingency allowance was used for real estate estimates, reflecting the preliminary nature of the estimates. Estimates of cost for engineering and design, and for supervision and administration are based on cost experienced for similar work in the Sacramento District. The apportionment of Federal and non-Federal first costs, presented in this chapter, is based on the traditional cost apportionment method. Detailed estimates of first costs are presented in Tables 29 through 34.

a. Summary of First Cost. - A summary of the project first cost by accounts is shown in Table 28.

Table 28

Detailed Summary of First Cost by Account
(x $1,000)

Acct. No.		Big Dry	Fancher	Pup	Alluvial	Redbank	Cultural & CP&E Funds	Project Total
I. Federal First Cost								
03.	Reservoir	80	80	12	12	20		204
04.	Dams	9,890	14,170	3,510	2,840	10,450		40,860
08.	Roads		50					50
09.	Channels and Canals	40						40
11.	Levees & Channels	370						370
18.	Culture Res. Pres.						400	400
19.	Bldg. Grds. Utilities	50						50
20.	Perm. Op. Equip.	180	25	10	10	10		235
30.	E & D	1,200	1,580	390	310	1,200		4,680
31.	S & A	490	695	178	128	520		2,011
	CP&E						700	700
	Total	12,300	16,600	4,100	3,300	12,200	1,100	49,600
II. Non-Federal First Cost								
	Lands and Damages	1,800	5,300	700	500	1,800		10,100
	Relocations	200	200					400
	Total	2,000	5,500	700	500	1,800		10,500
	Total Project Cost	14,300	22,100	4,800	3,800	14,000		60,100

Price Level, 1 Oct. 85

b. Detailed Cost Estimates. - Detailed estimates of the first cost of the project features are presented in Tables 29 through 33. Miscellaneous Accountable Funds are presented in Table 34. They are based on a 1 October 1985 price level.

Table 29

Detailed First Cost Estimate
Big Dry Creek Dam

ACCT. NO	DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT COST	TOTAL COST
I.	FEDERAL FIRST COST				
03.	RESERVOIR				
	PROJECT BOUNDERY SURVEY & MARKERS	1	JOB	LS	$ 80,000
	TOTAL RESERVOIR				$ 80,000
04.	DAMS				
	MAIN DAM CREST EL. 442.6				
	EXCAVATION				
	STRIPPING EXISTING DAM & FOUNDATION - 12" (TO WASTE)	136,600	CY	0.75	$ 102,450
	STRIPPING BORROW 6" (TO STOCKPILE/REPLACE/REPAIR)	120,600	CY	1.60	$ 192,960
	CUT-OFF TRENCH EXCAVATION (RANDOM 0.25 MI	160,000	CY	1.50	$240,000
	RAMP, 2 EACH (200 CY/PER)	400	CY	3.75	$ 1,500
	TURNAROUND, 2 EACH (500 CY/PER)	1,000	CY	3.50	$ 3,500
	RANDOM BORROW (0.5 MI)	1,165,000	CY	1.60	$1,864,000
	FILTER BORROW (0.5 MI)	34,000	CY	2.15	$ 73,100
	EXISTING EMBANKMENT (TO RANDOM 0.25 MI)	38,000	CY	1.20	$ 45,600
	RECENT ALLUVIUM (FOUNDATION WASTE)	141,000	CY	0.80	$ 112,800
	STRIPPING BORROW 4" FANCHER SITE (TO STOCKPILE/ REPLACE/REPAIR)	5,100	CY	1.75	$ 8,925
	SLOPE PROTECTION (SANDY CLAY) FANCHER SITE - 8 MI	45,600	CY	3.25	$ 148,200
	DRAINAGE FILL-(PROCESS GRAVEL) COMMERCIAL SOURCE - 12 MI)	67,600	TON	13.00	$ 878,800
	STABILIZED AGGREGATE 16' WIDE x 4" THICK COMMERCIAL SOURCE - 12 MI	8,900	TON	12.50	$ 111,250

Cost Estimates

Table 29 (Continued)

ACCT. NO	DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT COST	TOTAL COST
	EMBANKMENTS IN PLACE				
	RANDOM FILL				
	from cut-off trench	152,000	CY	0.75	$ 114,000
	from existing embankment	38,000	CY	0.75	$ 28,500
	from borrow	1,108,100	CY	0.75	$ 831,075
	FILTER MATERIAL	34,000	CY	1.25	$ 42,500
	from BIG DRY CREEK				
	DRAINAGE FILL	39,900	CY	2.75	$ 109,725
	COMMERCIAL SOURCE				
	SLOPE PROTECTION	40,100	CY	1.50	$ 60,150
	SANDY CLAY FROM FANCHER SITE				
	STAB. AGGR. ROAD SURFACE (16'x14")	5,000	CY	1.00	$ 5,000
	COMMERCIAL SOURCE				
	CONSTRUCTION FACILITIES	1	JOB	LS	$ 225,000
	DIVERSION & CARE OF WATER	1	JOB	LS	$ 75,000
	STRUCTURE & SITE ENCHANCEMENT	1	JOB	LS	$ 130,000
	SUBTOTAL				$5,404,035
	CONTINGENCIES	15.0%			$ 825,965
	TOTAL MAIN DAM				$6,230,000
	SPILLWAY - 550' WIDE OGEE				
	OGEE CREST EL. 433.2				
	EXCAVATION, UNCLASSIFIED	84,300	CY	3.00	$ 252,900
	CONCRETE:				
	approach walls:				
	formed	50	CY	230.00	$ 11,500
	unformed	57	CY	110.00	$ 6,270
	ogee section:				
	walls (formed)	147	CY	240.00	$ 35,280
	mass conc.	4,555	CY	100.00	$ 455,500
	stilling basin:				
	formed (baffel blocks)	91	CY	235.00	$ 21,385
	unformed	1,895	CY	95.00	$ 180,025
	grade control sill	1,422	CY	95.00	$ 135,090
	REINFORCEMENT	598,200	LBS	0.50	$ 299,100
	CEMENT	30,540	CWT	5.00	$ 152,700
	RIPRAP - (PLACE - COMM.SOURCE)	1,370	TON	15.00	$ 20,550
	RIPRAP - (REMOVAL)	1,390	CY	5.00	$ 6,950
	HANDRAILING	3,500	LBS	3.50	$ 12,250
	REMOVAL OF EXISTING CONCRETE	690	CY	100.00	$ 69,000
	STRUCTURE & SITE ENHANCEMENT	1	JOB	LS	$ 50,000
	SUBTOTAL				$1,708,500
	CONTINGENCIES		15%		$ 251,500
	TOTAL SPILLWAY				$1,960,000

Table 29 (Continued)

ACCT. NO	DESCRIPTION	ESTIMATED UNIT QUANTITY	UNIT COST	TOTAL COST
	OUTLET WORKS			
	LITTLE DRY CREEK OUTLET WORKS			
	EXCAVATION,THROUGH EXIST. DAM	12,350 CY	3.00	$ 37,050
	BACKFILL, ENGINEERED	11,400 CY	5.00	$ 57,000
	RIPRAP (COMMERCIAL SOURCE)	300 TON	16.00	$ 4,800
	CONCRETE- FORMED:			
	approach walls	42 CY	285	$ 11,970
	intake tower	300 CY	260	$ 78,000
	stilling basin	101 CY	220	$ 22,220
	CONCRETE- UNFORMED			
	approach slab	36 CY	145	$ 5,220
	control tower - slab	62 CY	145	$ 8,990
	stilling basin - slab	142 CY	95	$ 13,490
	bridge abutment slab	10 CY	180	$ 1,800
	CONCRETE-SPECIAL			
	conduit (formed)	124 CY	300	$ 37,200
	conduit (unformed)	55 CY	180	$ 9,900
	bridge deck	7 CY	290	$ 2,030
	abutment	3 CY	330	$ 990
	lean mix concrete	1,360 CY	90	$ 122,400
	REINFORCING	106,200 LBS	0.50	$ 53,100
	CEMENT	5,520 CWT	5.00	$ 27,600
	STRUCTURAL STEEL:			
	A-36 bridge girders	8,383 LBS	2.00	$ 16,766
	bearing pads (3/4" PL.)	65 LBS	5.00	$ 325
	bridge railing (1-1/2" PIPE)	1,082 LBS	3.50	$ 3,787
	trashracks	4,035 LBS	3.00	$ 12,105
	steel liner (1/4/" PL.)	1,950 LBS	5.00	$ 9,750
	MISCELLANEOUS METALS:			
	(HOISTS,DOORWAYS, & STAIRS)	5,000 LBS	3.50	$ 17,500
	AIR INTAKES (7" DIA.)	20 LF	15.00	$ 300
	DRAIN (4"DIA.)	165 LF	10.00	$ 1,650
	WATER STOPS	200 LF	12.50	$ 2,500
	GATE & EQUIPMENT	4 EA	40,000	$ 160,000
	(6.5'H X 3.0'W X 34'HD.)			
	ELECTRICAL SERVICE:			
	(460 V - 200 A - 3 PHASE	1 JOB	LS	$ 10,000
	GATE OPERATING CONTROLS	4 EA	10,000	$ 40,000
	INSTALLATION	1 JOB	LS	$ 40,000
	REMOVAL OF CONCRETE:			
	control tower	325 CY	100	$ 32,500
	conduit	165 CY	140	$ 23,100
	stilling basin	240 CY	90	$ 21,600
	bridge abutment	8 CY	250	$ 2,000
	REMOVAL OF STEEL			
	FOOT BRIDGE	36 LF	100	$ 3,600

Table 29 (Continued)

ACCT. NO	DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT COST	TOTAL COST
	REMOVAL OF MISCELLANEOUS METAL IN CONTROL TOWER	1	JOB	LS	$ 10,000
	REMOVAL OF GATE & EQUIPMENT	1	JOB	LS	$ 15,000
	FENCING	250	LF	10.00	$ 2,500
	STAFF GAUGES	1	JOB	LS	$ 5,000
	STRUCTURE & SITE ENHANCEMENT	1	JOB	LS	$ 20,000
	SUBTOTAL				$ 943,743
	CONTINGENCIES	15%			$ 146,257
	TOTAL LITTLE DRY CR. OUTLETWORKS				$1,090,000
	BIG DRY CREEK OUTLET WORKS				
	EXCAVATION, THROUGH EXISTING DAM	9,750	CY	3.00	$ 29,250
	EXCAVATION, AROUND EXIST. OUTLET	5,420	CY	3.50	$ 18,970
	EXCAVATION, NEW EXIT CHANNEL	1,180	CY	3.00	$ 3,540
	BACKFILL, ENGINEERED	17,200	CY	5.00	$ 86,000
	RIPRAP	55	TONS	16.00	$ 880
	CONCRETE, FORMED:				
	intake tower	173	CY	260.00	$ 44,980
	approach channel	19	CY	225.00	$ 4,275
	impact basin	23	CY	225.00	$ 5,175
	CONCRETE, UNFORMED				
	approach channel	25	CY	145.00	$ 3,625
	tower slab	39	CY	145.00	$ 5,655
	impact basin slab	19	CY	115.00	$ 2,185
	bridge abutment slab	11	CY	110.00	$ 1,210
	CONCRETE - SPECIAL				
	conduit (formed)	76	CY	300.00	$ 22,800
	conduit (unformed)	43	CY	145.00	$ 6,235
	bridge abutment	4	CY	265.00	$ 1,060
	bridge deck	10	CY	290.00	$ 2,900
	REINFORCING STEEL	56,250	LBS	0.50	$ 28,125
	CEMENT	2,775	CWT	5.00	$ 13,875
	STRUCTURAL STEEL:				
	A-36,bridge girders	22,300	LBS	2.00	$ 44,600
	bearing pads	85	LBS	5.00	$ 425
	bridge railings	1,450	LBS	3.50	$ 5,075
	trashrack	770	LBS	3.00	$ 2,310
	steel liner	610	LBS	3.00	$ 1,830
	MISCELLANEOUS METALS (HOIST DOORWAY & LADDER)	3,000	LBS	3.50	$ 10,500
	AIR INTAKE (6" DIA.)	10	LF	3.25	$ 33
	DRAIN (4" DIA.)	200	LF	10.00	$ 2,000
	WATER STOPS	150	LF	12.50	$ 1,875
	GATE AND EQUIPMENT (3.0'H X 3.0'W X 38.4' HD)	2	EA	25,000	$ 50,000

Table 29 (Continued)

ACCT. NO	DESCRIPTION	ESTIMATED UNIT QUANTITY	UNIT COST	TOTAL COST
	ELECTRICAL SERVICE			
	(460V - 200 AMP - 3 PHASE)	1 JOB	LS	$ 10,000
	GATE OPERATING CONTROLS	2 EA	10,000	$ 20,000
	INSTALLATION	1 JOB	LS	$ 14,000
	REMOVAL OF CONCRETE:			
	control tower	240 CY	100.00	$ 24,000
	stilling basin	195 CY	90.00	$ 17,550
	BRIDGE ABUTMENT	8 CY	250.00	$ 2,000
	REMOVAL OF STEEL			
	FOOT BRIDGE	36 LF	100.00	$ 3,600
	REMOVAL OF MISCELLANEOUS METAL			
	IN CONTROL TOWER	1 JOB	LS	$ 10,000
	REMOVAL OF GATE & EQUIPMENT	1 JOB	LS	$ 15,000
	PLUG EXISTING CONDUIT	8 CY	330.00	$ 2,640
	(5' CONC. PLUG IN EACH END)			
	STAFF GAUGES	1 JOB	LS	$ 5,000
	STRUCTURE & SITE ENHANCEMENT	1 JOB	LS	$ 10,000
	SUBTOTAL			$ 533,178
	CONTINGENCIES	15%		$ 76,822
	TOTAL BIG DRY CREEK OUTLET WORKS			$ 610,000
	TOTAL DAMS			$ 9,890,000
09.	CHANNELS AND CANALS			
	MOD. FIVE EXIST. DROP STRUCTURES			
	REMOVAL OF IMPROVEMENTS (FENCE)	3,500 LF	6.00	$ 21,000
	CLEAR (10' - 15' TREES)	10 EA	350.00	$ 3,500
	EXCAVATION	140 CY	5.00	$ 700
	BEDDING	80 CY	25.00	$ 2,000
	RIPRAP	220 TON	16.00	$ 3,520
	GATE (4' x 8')	1 EA	750.00	$ 750
	STRUCTURE & SITE ENHANCEMENT	1 JOB	LS	$ 3,000
	SUBTOTAL			$ 34,470
	CONTINGENCIES	15%+/-		$ 5,530
	TOTAL EXISITING DROP STRUCTURES			$ 40,000
11.	LEVEES & CHANNELS			
	BIG DRY CREEK LEVEE & CROSSING			
	SITE PREPERATION	1 JOB	LS	$ 10,000
	EXCAVATION:			
	Strip Borrow Area, 12" (waste)	1,150 CY	1.75	$ 2,013

Table 29 (Continued)

ACCT. NO	DESCRIPTION	ESTIMATED UNIT QUANTITY	UNIT COST	TOTAL COST
	Strip, 12" (waste)	5,150 CY	1.00	$ 5,150
	Impervious Borrow (6 mi.)	21,800 CY	10.00	$218,000
	EMBANKMENT IN PLACE:			
	Impervious Fill (From Borrow)	18,550 CY	1.25	$ 23,188
	SYPHON HEAD WALL			
	Concrete - Formed	26 CY	285.00	$ 7,410
	Concrete - Unformed	11 CY	180.00	$ 1,980
	Reinforcement	4,220 LBS	0.50	$ 2,110
	Cement	232 CWT	5.00	$ 1,160
	Rock Riprap	2,800 TON	16.00	$ 44,800
	STRUCTURE & SITE ENHANCEMENT	1 JOB	LS	$ 10,000
	SUBTOTAL			$325,810
	CONTINGENCIES	15%+/-		$ 44,190
	TOTAL DRY CREEK LEVEE AND SYPHON			$370,000
19.	BUILDINGS, GROUNDS & UTILITIES			
	MISCELLANEOUS STORAGE	1 JOB	LS	$ 40,000
	SUBTOTAL			$ 40,000
	CONTINGENCIES	15%		$ 10,000
	TOTAL BUILDINGS, GROUNDS, & UTILITIES			$ 50,000
20.	PERMANENT OPERATING EQUIPMENT			
	(STAFF GAUGES, FLOAT WELLS, PRECIPITATION GAUGE TELEPHONES, POOL GAUGES AND GATE OPERATING EQUIPMENT)	1 JOB	LS	$160,000
	SUBTOTAL			$160,000
	CONTINGECIES	15%		$ 20,000
	TOTAL PERMANENT OPERATING EQUIPMENT			$180,000
30.	ENGINEERING & DESIGN			$ 1,200,000
31.	SUPERVISION & ADMINISTRATION			$ 490,000
	TOTAL FEDERAL FIRST COST			$12,300,000
II.	NON-FEDERAL FIRST COST			
	LANDS & DAMAGES			
	LANDS FEE - DAMS AND OUTLET WORKS			
	LARGE AGRIC.	150 AC	800	$ 120,000
	FLOWAGE EASEMENT (PERMANENT FLOODING)			
	LARGE AGRIC.	64 AC	720	$ 46,080

Table 29 (Continued)

ACCT. NO	DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT COST	TOTAL COST
	FLOWAGE EASEMENT (OCCASIONAL FLOODING)				
	LARGE AGRIC.	2,628	AC	200	$ 525,600
	BORROW EASEMENT	500	AC	50	$ 25,000
	FLOOD PROTECTION LEVEE EASEMENT				
	OVERCHUTE AREA				
	LARGE AGRIC.	1.2	AC	720	$ 864
	ROAD EASEMENT-OVERCHUTE AREA	0.1	AC	400	$ 40
	TEMPORARY WORK AREA EASEMENT				
	- OVERCHUTE AREA				
	LARGE AGRIC.	12.0	AC	80	$ 960
	IMPROVEMENTS	1	LS	409,600	$ 409,600
	SUBTOTAL LANDS & IMPROVEMENTS				$1,128,144
	CONTINGENCIES	35.0%			$ 398,856
	RELOCATION COSTS	3.0	EA	15,000	$ 45,000
	ACQUISTION & ADMINISTRATION COSTS (PER OWNERSHIP)	38	EA	6,000	$ 228,000
	TOTAL LANDS & DAMAGES				$1,800,000
	RELOCATIONS				
	UTILITIES				
	RELOCATE 70 KV POWERLINE ON WOOD POLE. (50' SO. OF EXISTING LINE)	0.9	MI	75,000	$ 67,500
	RELOCATE 12 KV POWERLINE ON POLES SHARED W/70 KV LINE	0.3	MI	65,000	$ 19,500
	ABANDON 12 KV POWERLINE ON WOOD POLES	1.3	MI	40,000	$ 52,000
	SUBTOTAL				$ 139,000
	CONTINGENCIES	15.0%			$ 21,000
	TOTAL UTILITIES				$ 160,000
	TOTAL RELOCATIONS				$ 160,000
	ENGINEERING & DESIGN				$ 25,000
	SUPERVISION & ADMINISTRATION				$ 15,000
	TOTAL NON-FEDERAL FIRST COST				$ 2,000,000
	TOTAL FACILITY FIRST COST				$14,300,000

Cost Estimates

Table 30

Detailed First Cost Estimate
Fancher Creek Dam

ACCT. NO	DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT COST	TOTAL COST
I.	FEDERAL FIRST COST				
03.	RESERVOIR				
	RESERVOIR CLEARING (LT.-MOD.)	80.0	AC	275.00	$ 22,000
	REMOVAL OF IMPROVEMENTS		N/A		0
	SUBTOTAL				$ 22,000
	CONTINGENCIES	15.0%			$ 5,500
	SUBTOTAL				$ 27,500
	PROJECT BOUNDERY SURVEY & MARKERS	1.0	LS	52,500	$ 52,500
	TOTAL RESERVOIR				$ 80,000
04.	DAMS				
	MAIN DAM CREST EL. 493.3				
	MOBILIZATION	1.0	LS	25,000	$ 25,000
	DEWATER SITE D/S OF SPILLWAY	1.0	LS	25,000	$ 25,000
	EXCAVATION				
	STRIPPING FOUNDATION 24" & DIKE REMOVAL				
	FOR SLOPE PROTECTION (STK'PL.)	178,000	CY	0.80	$ 142,400
	FOR U/S IMP. BLANKET (STK'PL.)	23,000	CY	0.80	$ 18,400
	DIKE REMOVAL				
	(USE AS SLOPE PROTECTION-STK'PL)	39,400	CY	1.00	$ 39,400
	INSPECTION TRENCH EXC. (IMPERVIOUS) 0.25 MI.	122,000	CY	1.60	$ 195,200
	TOE TRENCH EXC. (RANDOM) 0.25 MI.	16,000	CY	1.75	$ 28,000
	STRIPPING BORROW (REPLACE)	300,000	CY	1.80	$ 540,000
	IMPERVIOUS BORROW (0.6 MI.)	426,000	CY	1.75	$ 745,500
	RANDOM BORROW (0.6 MI.)	1,396,000	CY	1.75	$2,443,000
	FILTER (FROM BIG DRY CREEK DAM SITE - 8 MI.)	67,000	CY	3.50	$ 234,500
	DRAINAGE FILL - (PROCESSED GRAVEL-COMMERCIAL- 20 MI.)	75,000	CY	17.25	$1,293,750
	STAB. AGG.- (COMMERCIAL 20 MI.)	3,000	CY	17.00	$ 51,000
	EMBANKMENT (IN PLACE)				
	RANDOM FILL				
	FROM TOE TRENCH	15,000	CY	0.90	$ 13,500
	FROM BORROW AREA	1,326,000	CY	2.20	$2,917,200
	FILTER CLOTH	33,000	SY	1.00	$ 33,000
	FILTER MATERIAL (BIG DRY 8 MI.)	67,000	CY	0.90	$ 60,300

Cost Estimates

Table 30 (Continued)

ACCT. NO	DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT COST	TOTAL COST
	IMPERVIOUS FILL				
	FROM INSPECTION TRENCH	107,000	CY	0.90	$ 96,300
	FROM BORROW AREA	375,000	CY	0.75	$ 281,250
	SLOPE PROTECTION (FROM FOUNDATION STRIPPING)	178,000	CY	2.20	$ 391,600
	UPSTREAM IMPERVIOUS BLANKET (FROM FOUNDATION STRIPPING)	23,000	CY	2.20	$ 50,600
	U/S TOE LEVELING (FROM DIKE REMOVAL & FOUNDATION STRIPPING)	53,800	CY	2.20	$ 118,360
	DRAINAGE FILL-(PROCESSED GRAVEL - COMMERCIAL)	75,000	CY	4.00	$ 300,000
	STABALIZED AGGREGATE (16' WIDE X 4" THICK- COMMER.)	3,000	CY	4.00	$ 12,000
	DRAINAGE SYSTEM:				
	18" SLOTTED CMP	10,000	LF	27.00	$ 270,000
	CONSTRUCTION FACILITIES	1.0	LS	175,000	$ 175,000
	DIVERSION & CARE OF WATER	1.0	LS	75,000	$ 75,000
	STRUCTURE & SITE ENHANCEMENT	1.0	LS	260,000	$ 260,000
	SUBTOTAL				$10,835,260
	CONTINGENCIES	15.0%			$ 1,624,740
	MAIN DAM SUBTOTAL				$12,460,000
	COMBINED SPILLWAY AND OUTLET WORKS				
	EXCAVATION, (TO IMP. STK'PL.)	17,000	CY	3.00	$ 51,000
	SELECT FILL	250	CY	5.00	$ 1,250
	ENGINEERED FILL	1,980	CY	6.00	$ 11,880
	BACKFILL (from IMP.STK'PL.)	2,600	CY	5.00	$ 13,000
	IMPERVIOUS FILL	1,370	CY	6.00	$ 8,220
	DRAINAGE FILL	1,220	CY	20.75	$ 25,315
	CONCRETE FORMED:				
	APPROACH WALLS	180	CY	235	$ 42,300
	INTAKE CONTROL SECTION WALL	420	CY	240	$ 100,800
	ABUTMENT WALLS	240	CY	205	$ 49,200
	SPILLWAY CHUTE WALLS	230	CY	250	$ 57,500
	MODIFY EXISTING STILLING BASIN RAISE EXISTING OVERCHUTE WALLS, BRIDGE DECK AND BEAMS	45	CY	300	$ 13,500
	PARABOLIC DROP STRUCTURE WALLS	120	CY	260	$ 31,200
	NEW STILLING BASIN WALLS	265	CY	240	$ 63,600
	ENDSILL & D/S CUTOFF WALLS	20	CY	275	$ 5,500
	STILLING BASIN-BAFFELS	15	CY	300	$ 4,500
	COUNTERFORT	70	CY	275	$ 19,250
	CONCRETE UNFORMED:				
	LEAN MIX CONCRETE				
	ABUTMENT & OGEE SECTION SLAB	120	CY	90	$ 10,800
	APPROACH SLAB	220	CY	110	$ 24,200

Table 30 (Continued)

ACCT. NO	DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT COST	TOTAL COST
	INTAKE STRUCTURE SLAB	380	CY	125	$ 47,500
	SPILLWAY CHUTE SLAB	750	CY	110	$ 82,500
	PARABOLIC DROP STRUCTURE SLAB	170	CY	125	$ 21,250
	STILLING BASIN SLAB	350	CY	110	$ 38,500
	MASS CONCRETE				
	OGEE SECTION	1,770	CY	125	$ 221,250
	APRON-INTAKE SECTION	40	CY	145	$ 5,800
	REINFORCEMENT	501,000	LBS	0.50	$ 250,500
	CEMENT	33,000	CWT	5.00	$ 165,000
	STEEL TRASHRACK	2,200	LBS	3.00	$ 6,600
	BRIDGE RAILING,METAL (OVERCHUTE)	200	LF	25.00	$ 5,000
	BRIDGE BUFFER (4" X 8" WOOD)	50	LF	15.00	$ 750
	DRAIN PIPE - 1" DIA.	230	LF	10.00	$ 2,300
	DERRICK STONE	960	CY	24.00	$ 23,040
	MODIFICATION OF EXISTING OVERCHUTE STRUCTURE:				
	REMOVE EXIST. CONCRETE (230 CY)	1.0	LS	20,000	$ 20,000
	REMOVE EXISTING GUARD RAILING (82 LF.)	1.0	LS	1,000	$ 1,000
	CHAIN LINK FENCE	900	LF	8.00	$ 7,200
	MISCELLANEOUS METALS	1,000	LBS	3.50	$ 3,500
	RIPRAP	3,170	TON	10	$ 31,700
	SAND & GRAVEL	210	CY	20	$ 4,200
	GRAVEL & COBBLES	220	CY	21	$ 4,620
	PAINTING, TESTING, ETC.	1.0	LS	10,000	$ 10,000
	STRUCTURE & SITE ENHANCEMENT	1.0	LS	40,000	$ 40,000
	SUBTOTAL				$ 1,525,225
	CONTINGENCIES	15.0%			$ 184,775
	COMBINED SPILLWAY AND OUTLET WORKS TOTAL				$ 1,710,000
	TOTAL DAMS				$14,170,000
08.	ROADS				
	ACCESS ROAD	1.0	LS	45,000	$ 45,000
	SUBTOTAL				$ 45,000
	CONTINGENCIES	15.0%			$ 5,000
	TOTAL ROADS				$ 50,000

Cost Estimates

Table 30 (Continued)

ACCT. NO	DESCRIPTION	ESTIMATED UNIT QUANTITY	UNIT COST	TOTAL COST
20.	PERMANENT OPERATING EQUIPMENT			
	(STAFF GAUGES, PRECIPITATION GUAGE, POOL GAUGES AND OUTFLOW STATIONS)	1.0 LS	22,500	$ 22,500
	SUBTOTAL			$ 22,500
	CONTINGECIES	15.0%		$ 2,500
	TOTAL PERMANENT OPERATING EQUIPMENT			$ 25,000
30.	ENGINEERING & DESIGN			$ 1,580,000
31.	SUPERVISION & ADMINISTRATION			$ 695,000
	TOTAL FEDERAL FIRST COST			$16,600,000
II.	NON-FEDERAL FIRST COST			
	LANDS & DAMAGES			
	LAND FEE			
	SMALL AGRICULTURE	67 AC	4,000	$ 268,000
	LARGE AGRICULTURE	60 AC	1,000	$ 60,000
	LAND EASEMENT (OCCASIONAL FLOODING)			
	SMALL AGRICULTURE	625 AC	3,500	$ 2,187,500
	LARGE AGRICULTURE	546 AC	500	$ 273,000
	VINEYARD	80 AC	5,500	$ 440,000
	BORROW EASEMENT	275 AC	140	$ 38,500
	IMPROVEMENTS			
	3 HOUSES & MISC. IMPROVMENTS	1.0 LS	362,500	$ 362,500
	SUBTOTAL LANDS & IMPROVEMENTS			$ 3,629,500
	CONTINGENCIES	35.0%		$ 1,265,500
	RELOCATION COSTS	3.0 EA	15,000	$ 45,000
	ACQUISTION & ADMINISTRATION COSTS (PER OWNERSHIP)	60 LS	6,000	$ 360,000
	TOTAL LANDS & DAMAGES			$ 5,300,000

Cost Estimates

Table 30 (Continued)

ACCT. NO	DESCRIPTION	ESTIMATED UNIT QUANTITY	UNIT COST	TOTAL COST
	RELOCATIONS			
	UTILITIES			
	ABANDON AND REMOVE 12-KV 3 WIRE POWERLINE ON WOOD POLES	2.6 MI	27,500	$ 71,500
	ABANDON AND REMOVE 3 WIRE SERVICES POWERLINE ON WOOD POLES	1.3 MI	17,500	$ 22,750
	ABANDON AND REMOVE 2 WIRE TELEPHONE LINES ON WOOD POLES	3.9 MI	12,500	$ 48,750
	SUBTOTAL			$ 143,000
	CONTINGENCIES	15.0%		$ 17,000
	TOTAL RELOCATIONS			$ 160,000
	ENGINEERING & DESIGN			$ 30,000
	SUPERVISION & ADMINISTRATION			$ 10,000
	TOTAL NON-FEDERAL FIRST COST			$ 5,500,000
	TOTAL FACILITY FIRST COST			$22,100,000

Cost Estimates

Table 31

Detailed First Cost Estimate
Pup Creek Detention Basin

ACCT. NO	DESCRIPTION	ESTIMATED UNIT QUANTITY	UNIT COST	TOTAL COST
I.	FEDERAL FIRST COST			
03.	RESERVOIR			
	PROJECT BOUNDERY SURVEY & MARKERS	1.0 JOB	LS	$ 12,000
	TOTAL RESERVOIR			$ 12,000
04.	DAMS			
	MOBILIZATION & PREP . WORK	1.0 JOB	LS	$ 25,000
	DETENTION DIKE (INV. 366.0+/-)			
	STRIP, STKPL. & RESTORE TOPSOIL	94,700 CY	1.75	$ 165,725
	EXC. (UNCLS.)(TO WASTE 1.0 MI.)	975,200 CY	2.25	$2,194,200
	STRUCTURE & SITE ENHANCEMENT	1 JOB	LS	$ 60,000
	SUBTOTAL			$2,444,925
	CONTINGENCIES	15.0%		$ 365,075
	TOTAL DETENTION BASIN			$2,810,000
	OUTLET WORKS & EXIT CHANNEL			
	EXC. UNCLAS. (TRENCH-6,500 CY - OPEN CHAN. O/W-8,400 CY - WASTE 1	14,900 CY	3.00	$ 44,700
	BACKFILL STRUCTURAL	1,510 CY	6.00	$ 9,060
	BACKFILL TO GROUND LINE	3,640 CY	5.00	$ 18,200
	BEDDING (FOR TRENCH)	640 TON	14	$ 8,960
	RCP, 48" DIA.(1 EA. 2320' EA.)	2,320 LF	100	$ 232,000
	CONCRETE, FORMED			
	INTAKE STRUCTURE	13 CY	325	$ 4,225
	CONDUIT	33 CY	300	$ 9,900
	HEADWALL	22 CY	270	$ 5,940
	CONCRETE, UNFORMED			
	INTAKE STRUCTURE	18 CY	145	$ 2,610
	CONDUIT	18 CY	165	$ 2,970
	HEADWALL	36 CY	125	$ 4,500

Cost Estimates

Table 31 (Continued)

ACCT. NO	DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT COST	TOTAL COST
	ROCK RIPRAP BASIN				
	FILTER MATERIAL	60	CY	22	$ 1,320
	ROCK	181	TON	15	$ 2,715
	GROUT	20	CY	100	$ 2,000
	INLET SLOPE PROTECTION				
	SOIL CEMENT	1,120	CY	40	$ 44,800
	CEMENT	4,710	CWT	5.00	$ 23,550
	EXCAVATION	1,120	CY	5.00	$ 5,600
	ROCK (FOR RIPRAP)	660	TON	22	$ 14,520
	EMBANKMENT SECTION				
	EXCAVATION	200	CY	5.00	$ 1,000
	12" STRIPPING	1,380	CY	2.50	$ 3,450
	BACKFILL	1,980	CY	5.00	$ 9,900
	SLOPE PROTECTION				
	SOIL CEMENT	1,555	CY	40	$ 62,200
	CEMENT	6,550	CWT	5.00	$ 32,750
	METAL TRASHRACK	80	LBS	3.00	$ 240
	REINFORCEMENT	16,000	LBS	0.50	$ 8,000
	CEMENT	890	CWT	5.00	$ 4,450
	MISC. STEEL (FLOW RESTRICTOR)	40	LBS	4.50	$ 180
	RCP, 36" DIA.	66	LF	75	$ 4,950
	FLARED END SECTIONS	1.0	EA	1,000	$ 1,000
	MANHOLE (9' DEEP)	5.0	EA	2,500	$ 12,500
	ROCK RIPRAP (AT U/S SIDE OF TEMPERANCE AVE.)	70	TON	16	$ 1,120
	REMOVE & DISP. OF EXIST. CLVTS.				
	24" RCP	80	LF	50	$ 4,000
	3 STRAND BARB WIRE (640'X 2)	1,280	LF	2.50	$ 3,200
	S.A.B.C. (ROAD-12'W X 6" THICK)	225	TON	14	$ 3,150
	STRUCTURE & SITE ENHANCEMENT	1.0	JOB	LS	$ 15,000
	SUBTOTAL				$ 604,660
	CONTINGENCIES	15.0%			$ 95,340
	OUTLET WORKS TOTAL				$ 700,000
	TOTAL DAMS				$3,510,000
20.	<u>PERMANENT OPERATING EQUIPMENT</u>				
	(STAFF GAUGES AND POOL GAUGES)	1	JOB	LS	$ 8,500
	SUBTOTAL				$ 8,500
	CONTINGENCIES	15.0%			$ 1,500
	TOTAL PERMANENT OPERATING EQUIPMENT				$ 10,000
30.	<u>ENGINEERING & DESIGN</u>				$ 390,000

Cost Estimates

Table 31 (Continued)

ACCT. NO	DESCRIPTION	ESTIMATED UNIT QUANTITY	UNIT COST	TOTAL COST
31.	SUPERVISION & ADMINISTRATION			$ 178,000
	TOTAL FEDERAL FIRST COST			$4,100,000
II.	NON-FEDERAL FIRST COSTS			
	LANDS & DAMAGES			
	LANDS (FEE) - EMBANKMENT	1.1 AC	6,000	$ 6,600
	LANDS (FEE) CHANNELIZATION	1.1 AC	30,000	$ 33,000
	LAND (EASMENT) OCCAS'L. FLOODING	64 AC	5,000	$ 320,000
	LAND (EASMENT) TEMP. CONST.	3.2 AC	3,000	$ 9,600
	LAND (EASMENT) PIPELINE	1.1 AC	22,500	$ 24,750
	IMPROVEMENTS	1.0 JOB	LS	$ 19,500
	SUBTOTAL LANDS & IMPROVEMENTS			$ 413,450
	CONTINGENCIES	35.0%		$ 136,550
	RELOCATION COSTS	1.0 EA	0	0
	ACQUISTION & ADMINISTRATION COSTS PER OWNERSHIP	25.0 EA	6,000	$ 150,000
	TOTAL LANDS & DAMAGES			$ 700,000
	TOTAL NON-FEDERAL FIRST COST			$ 700,000
	TOTAL FACILITY FIRST COST			$4,800,000

Table 32

Detailed First Cost Estimate
Alluvial Drain Detention Basin

ACCT. NO	DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT COST	TOTAL COST
I.	FEDERAL FIRST COST				
03.	RESERVOIR				
	PROJECT BOUNDERY SURVEY & MARKERS	1.0	JOB	LS	$ 12,000
	TOTAL RESERVOIR				$ 12,000
04.	DAMS				
	MOBILIZATION & PREP . WORK	1.0	JOB	LS	$ 30,000
	STRIP, STKPL. & RESTORE TOPSOIL (12")	85,200	CY	1.70	$ 144,840
	EXCAVATION, UNCLASSIFIED	685,900	CY	2.80	$1,920,520
	TO DRY CREEK DAM				
	(340,000 CY - 1.5 MI)				
	TO WASTE (345,900 CY 1.0 MI.)				
	ROCK SLOPE PROTECTION	90	CY	22	$ 1,980
	SOIL CEMENT	600	CY	40	$ 24,000
	CEMENT	2,520	CWT	5.00	$ 12,600
	STRUCTURE & SITE ENHANCEMENT	1	LS	50,000	$ 50,000
	SUBTOTAL				$2,183,940
	CONTINGENCIES	15.0%			$ 326,060
	TOTAL DETENTION BASIN				$2,510,000
	OUTLET WORKS & EXIT CHANNEL				
	EXCAVATION, UNCLASSIFIED	1,200	CY	3.00	$ 3,600
	BACKFILL, STRUCTURAL	720	CY	6.00	$ 4,320
	ROCK SLOPE PROTECTION	140	CY	22	$ 3,080
	GROUTING ROCK PROTECTION	25	CY	90	$ 2,250
	FILTER MATERIAL	35	CY	20	$ 700
	CONCRETE, FORMED				
	INTAKE STRUCTURE	9.0	CY	365	$ 3,285
	CONDUIT	54	CY	300	$ 16,200
	EXIT STRUCTURE	10	CY	365	$ 3,650

Table 32 (Continued)

ACCT. NO	DESCRIPTION	ESTIMATED UNIT QUANTITY	UNIT COST	TOTAL COST
	CONCRETE, UNFORMED			
	INTAKE STRUCTURE	8.0 CY	180	$ 1,440
	CONDUIT	30 CY	165	$ 4,950
	EXIT STRUCTURE	12 CY	165	$ 1,980
	REINFORCEMENT	10,500 LBS	0.50	$ 5,250
	CEMENT	950 CWT	5.00	$ 4,750
	RCP, 36" DIA.	112 LF	75	$ 8,400
	METAL TRASHRACK	80 LBS	3.00	$ 240
	METAL FLOW RESTRICTOR	230 LBS	4.50	$ 1,035
	DIVERSION & CARE OF WATER			
	DIVERSION OF ENTERPRISE CANAL	1 JOB	LS	$ 170,000
	DOWNSTREAM CHANNEL IMPROVEMENT			
	EXCAVATION, UNC. (TO EMB.)	2,400 CY	3.00	$ 7,200
	EMBANKMENT (IN PLACE)	2,000 CY	4.00	$ 8,000
	S.A.B.C.	450 CY	20	$ 9,000
	FENCING (5 STRAND BARB WIRE)	4,000 LF	2.50	$ 10,000
	ARMSTRONG AVE. CULVERT			
	REMOVE & DISPOSE EXT. CULVERT	1.0 LS	1,500	$ 1,500
	EXCAVATION, UNC.	50 CY	3.00	$ 150
	BACKFILL	30 CY	5.00	$ 150
	50" X 31" ARCH PIPE (NEW)	60 LF	100	$ 6,000
	STRUCTURE & SITE ENHANCEMENT	1.0 LS	1,000	$ 7,000
	SUBTOTAL			$ 284,130
	CONTINGENCIES	15.0%		$ 45,870
	TOTAL OUTLET WORKS			$ 330,000
	TOTAL DAMS			$2,840,000
20.	PERMANENT OPERATING EQUIPMENT			
	(STAFF GAUGES AND POOL GAUGES)	1 LS		$ 8,000
	SUBTOTAL			$ 8,000
	CONTINGENCIES	15.0%		$ 2,000
	TOTAL PERMANENT OPERATING EQUIPMENT			$ 10,000

Cost Estimates

Table 32 (Continued)

ACCT. NO	DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT COST	TOTAL COST
30.	ENGINEERING & DESIGN				$ 310,000
31.	SUPERVISION & ADMINISTRATION				$ 128,000
	TOTAL FEDERAL FIRST COST				$3,300,000
II.	NON-FEDERAL FIRST COST				
	LANDS & DAMAGES				
	LANDS (FEE)	3.0	AC	20,000	$ 60,000
	LAND (EASEMENT)	57	AC	5,000	$ 285,000
	IMPROVEMENTS	N/A		0.00	0
	SUBTOTAL LANDS & IMPROVEMENTS				$ 345,000
	CONTINGENCIES	35.0%			$ 95,000
	RELOCATION COSTS				
	ACQUISITION & ADMINISTRATION COSTS PER OWNERSHIP	10.0	EA	6,000	$ 60,000
	TOTAL LANDS & DAMAGES				$ 500,000
	TOTAL NON-FEDERAL FIRST COST				$ 500,000
	TOTAL FACILITY FIRST COST				$3,800,000

Table 33

Detailed First Cost Estimate
Redbank Creek Detention Basin

ACCT. NO	DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT COST	TOTAL COST
I.	FEDERAL FIRST COST				
03.	RESERVOIR				
	PROJECT BOUNDARY SURVEY & MARKERS	1	JOB	LS	$ 20,000
	TOTAL RESERVOIR				$ 20,000
04.	DAMS				
	MAIN DAM				
	DETENTION BASIN (INV.342.2)				
	BASIN EXCAVATION:				
	MOBILIZATION & PREP. WORK	1	JOB	LS	$ 50,000
	PREP. WORK RESERVOIR AREA	1	JOB	LS	$ 20,000
	STRIP, STKPL. & RESTORE TOPSOIL	247,300	CY	1.75	$ 432,775
	EXCAVATION, UNCLASSIFIED	1,994,400	CY	3.50	$6,980,400
	TO EMBANKMENT (6,200 CY)				
	TO WASTE (1,987,800 CY @ 2 MI)				
	STRUCTURE & SITE ENHANCEMENT	1	JOB	LS	$ 190,000
	SUBTOTAL				$7,673,175
	CONTINGENCIES			15.0	$1,146,825
	BASIN EXCAVATION TOTAL				$8,820,000
	MILL DITCH				
	EXCAVATION UNCLASS. (TO WASTE)	116,800	CY	3.50	$ 406,000
	CHANNEL LINING	43,800	SF	4.50	$ 197,100
	(RENO MATTRESS - 9" THICK)				
	COBBLES	1,215	CY	21.00	$ 25,515
	BEDDING	1,130	CY	19.00	$ 21,470
	RIPRAP	1,880	TON	13.50	$ 25,380
	STRUCTURE & SITE ENHANCEMENT	1	JOB	LS	$ 20,000
	SUBTOTAL				$ 695,465
	CONTINGENCIES	15.0%			$ 104,535
	MILL DITCH TOTAL				$ 800,000
	CONTROL STRUCTURE (GATED)				
	EXCAVATION, UNCLASSIFED	2,800	CY	3.00	$ 8,400
	BACKFILL (BEHIND WALL)	1,500	CY	5.00	$ 7,500
	ENGINEERED FILL	350	CY	6.00	$ 2,100

Table 33 (Continued)

ACCT. NO	DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT COST	TOTAL COST
	CONCRETE				
	WINGWALLS				
	- FORMED	225	CY	300	$ 67,500
	- UNFORMED	130	CY	145	$ 18,850
	CONTROL STRUCTURE				
	- BELOW INVERT	135	CY	180	$ 24,300
	- ABOVE INVERT	90	CY	325	$ 29,250
	LEAN MIX	100	LF	90.00	$ 9,000
	REINFORCEMENT	70,000	LBS	0.50	$ 35,100
	CEMENT	4,100	CWT	5.00	$ 20,500
	CONSTANT D/S LEVEL GATE (AVIO 140 H)	2	EA	70,000	$ 140,000
	HANDRAILING	280	LF	20.00	$ 5,600
	RIPRAP	40	TON	14.00	$ 560
	BEDDING	10	CY	20.00	$ 200
	CONSTRUCTION ACCESS ROADS (24'W.)	2,000	LF	7.50	$ 15,000
	CARE & DIVERSION OF WATER	1	JOB	LS	$ 10,000
	STRUCTURE & SITE ENHANCEMENT	1	JOB	LS	$ 10,000
	SUBTOTAL				$ 403,860
	CONTINGENCIES	15.0%			$ 56,140
	CONTROL SECTION TOTAL				$ 460,000
	EMBANKMENT SECTION				
	STRIPPING	4,100	CY	3.00	$ 12,300
	EXCAVATION, UNCLASS.	4,600	CY	5.00	$ 23,000
	SOIL CEMENT	4,010	CY	40.00	$ 160,400
	CEMENT	16,900	CWT	5.00	$ 84,500
	STRUCTURAL BACKFILL	5,300	CY	6.00	$ 31,800
	STRUCTURE & SITE ENHANCEMENT	1	JOB	LS	$ 10,000
	SUBTOTAL				$ 322,000
	CONTINGENCIES	15.0%			$ 48,000
	EMBANKMENT SECTION TOTAL				$ 370,000
	TOTAL DAMS				$10,450,000
20.0	PERMANENT OPERATING EQUIPMENT				
	GATE EQUIP., STAFF GAUGES & FLOAT WELL WITH REMOTELY INTERROGATABLE RECORDERS	1	JOB	LS	$ 8,000
	SUBTOTAL				$ 8,000
	CONTINGENCIES	15.0%			$ 2,000
	TOTAL PERMANENT OPERATING EQUIPMENT				$ 10,000
30.	ENGINEERING & DESIGN				$ 1,200,000

Table 33 (Continued)

ACCT. NO	DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT COST	TOTAL COST
31.	SUPERVISION & ADMINISTRATION				$ 520,000
	TOTAL FEDERAL FIRST COST				$12,200,000
II.	NON-FEDERAL FIRST COST				
	LANDS & DAMAGES				
	LANDS (FEE)	28	AC	10,000	$ 280,000
	LAND (EASEMENT)	144	AC	7,000	$ 1,008,000
	IMPROVEMENTS	1	JOB	LS	$ 24,400
	SUBTOTAL LANDS & IMPROVEMENTS				$ 1,312,400
	CONTINGENCIES	35.0%			$ 445,600
	RELOCATION COSTS				
	ACQUISITION & ADMINISTRATION COSTS (PER OWNERSHIP)	7	EA	6,000	$ 42,000
	TOTAL LANDS & DAMAGES				$ 1,800,000
	TOTAL NON-FEDERAL FIRST COSTS				$ 1,800,000
	TOTAL FACILITY FIRST COST				$14,000,000

Cost Estimates

Table 34

Miscellaneous Accountable Funds

ACCT NO	DESCRIPTION	ESTIMATED UNIT QUANTITY	UNIT COST	TOTAL COST
	CULTURAL RESOURCES CONSIDERATIONS			
18.	CULTURAL RESOURCES PRESERVATION	1 JOB	LS	$ 345,000
30.	ENGINEERING AND DESIGN			$ 40,000
31.	SUPERVISION AND ADMINISTRATION			$ 15,000
	TOTAL CULTURAL RESOURCES			$ 400,000
	PROJECT CONTINUING PLANS, AND ENGINEERING			
30.	ENGINEERING AND DESIGN			$ 530,000
31.	SUPERVISION AND ADMINISTRATION			$ 170,000
	TOTAL C.P.&E.			$ 700,000
	TOTAL MISCELLANEOUS FUNDS			$1,100,000

Cost Estimates

104. Comparison of First Cost Estimates. - Comparisons of cost estimates for the current plan, the ASA's Recommended Plan, the Recommended Plan, and the Feasibility Plan are presented in Table 35.

Table 35

Comparison of Feasibility Report, ASA Recommended Plan and Current First Costs

ACCT. NO.		FEASIBILITY REPORT 1 OCT 78 (x $1,000)	ASA RECOMMENDED PLAN 1 OCT 78 (x $1,000)	ASA RECOMMENDED PLAN 1 OCT 85 (x $1,000)	CURRENT COST ESTIMATE 1 OCT 85 (x $1,000)
I.	FEDERAL FIRST COST				
A.	BIG DRY CREEK DAM				
03.	RESERVOIRS	260	190	300	80
	Reservoir Clearing	210	142	225	0
	Boundry Survey & Marks	50	47	75	80
04.	DAM	11,850	7,116	11,260	9,890
	Main Dam	8,000	4,354	6,890	6,230
	Spillway	1,480	1,631	2,580	1,960
	Little Dry Creek Outlet Works	1,240	752	1,190	1,090
	Big Dry Creek Outlet Works	1,130	379	600	610
09.	CHANNELS & CANALS	150	28	45	40
11.	LEVEES & CHANNELS	0	0	0	370
14.	RECREATION	950	0	0	0
19.	B. G. & U.	20	32	50	50
20.	PER. OP. EQUIP.	140	126	200	180
30.	E & D	1,700	828	1,310	1,200
31.	S & A	1,130	300	635	
490					
	TOTAL	16,200	8,620	13,800	12,300
B.	FANCHER CREEK DAM				
03.	RESERVOIR	230	70	110	80
	Reservoir Clearing	195	37	58	27
	Boundry Survey & Marks	35	33	52	53
04.	DAMS	14,700	9,278	14,680	14,170
	Main Dam	13,200	7,913	12,520	12,460
	Combined Spillway & Outlet	1,500	1,365	2,160	1,710
08.	ROADS	30	38	60	50
19.	BLDG. GRDS. UTILITIES	80	0	0	0
20.	PERM. OP. EQUIP.	15	19	30	25
30.	E & D	1,935	1,062	1,680	1,580
31.	S & A	1,260	483	740	
695					
	TOTAL	18,250	10,950	17,300	16,600

Cost Estimates

Table 35 (Continued)

Comparison of Feasibility Report and Current First Costs

ACCT. NO		FEASIBILITY REPORT (1 OCT 78) (x $1,000)	ASA RECOMMENDED PLAN (1 OCT 78) (x $1,000)	ASA RECOMMENDED PLAN (1 OCT 85) (x $1,000)	CURRENT COST ESTIMATE (1 OCT 85) (x $1,000)
C.	PUP CREEK DETENTION BASIN				
03.	RESERVOIRS	10	10	16	12
	Reservoir Clearing	5	5	8	0
	Boundary Survey & Marks	5	5	8	12
04.	DAMS	328	328	519	3,510
	Detention Basin	215	215	340	2,810
	Spillway	70	70	111	0
	Outlet Works	43	43	68	700
20.	PERM. OP. EQUIP.	2	2	3	10
30.	E & D	40	40	64	390
31.	S & A	30	30	48	178
	TOTAL	410	410	650	4,100
D.	ALLUVIAL DRAIN DETENTION BASIN				
03.	RESERVOIRS	10	10	16	12
	Reservoir Clearing	5	5	8	0
	Boundary Survey & Marks	5	5	8	12
04.	DAMS	502	502	794	2,840
	Detention Basin	135	135	214	2,510
	Spillway	297	297	470	0
	Outlet Works	70	70	110	330
20.	PERM. OP. EQUIP.	3	3	5	10
30.	E & D	65	65	103	310
31.	S & A	40	40	62	128
	TOTAL	620	620	980	3,300
E.	REDBANK CREEK DETENTION BASIN				
03.	RESERVOIR	10	24	38	20
	Reservoir Clearing	0	15	23	0
	Boundary Survey & Marks	10	9	15	20
04.	DAMS	6,000	5,637	8,920	10,450
20.	PERM. OP. EQUIP.	5	6	10	10
30.	E & D	740	619	980	1,200
31.	S & A	495	284	452	520
	TOTAL	7,250	6,570	10,400	12,200
F.	CULTURAL RESOURCES				
18.	CULTURAL RES. PRESERV.	0	0	0	400
G.	CP&E FUNDS	0	0	0	700
	TOTAL FEDERAL FIRST COST	42,730	27,170	43,130	49,600

Cost Estimates

Table 35 (Continued)

Comparison of Feasibility Report
and Current First Costs

ACCT. NO.	FEASIBILITY REPORT (1 OCT 78) (x $1,000)	ASA RECOMMENDED PLAN (1 OCT 78) (x $1,000)	ASA RECOMMENDED PLAN (1 OCT 85) (x $1,000)	CURRENT COST ESTIMATE (1 OCT 85) (x $1,000)
II. NON-FEDERAL FIRST COST				
A. BIG DRY CREEK DAM				
Lands and Damages	1,650	787	1,240	1,800
Relocations	350	133	210	200
TOTAL	2,000	920	1,450	2,000
B. FANCHER CREEK DAM				
Lands and Damages	4,675	2,377	3,760	5,300
Relocations	35	133	210	200
TOTAL	4,710	2,510	3,970	5,500
C. PUP CREEK DETENTION BASIN				
Lands and Damages	1,760	1,760	2,780	700
TOTAL	1,760	1,760	2,780	700
D. ALLUVIAL DRAIN DETENTION BASIN				
Lands and Damages	410	410	650	500
TOTAL	410	410	650	500
E. REDBANK CREEK DETENTION BASIN				
Land and Damages	760	1,140	1,800	1,800
TOTAL	760	1,140	1,800	1,800
TOTAL NON-FEDERAL FIRST COST	9,640	6,740	10,650	10,500
TOTAL PROJECT COST	52,370	33,910	53,780	60,100

Cost Estimates

105. Changes in First Costs. -

a. Feasibility Report ('78) to ASA's Recommended Plan ('78). - Changes in first costs from the Feasibility Report (1 Oct '78) to the ASA's Recommended Plan (1 Oct '78) are shown in Table 35. The net change in cost for these two plans is shown and explained in Table 36.

Table 36

Explanations of Cost
Changes from
Feasibility Report ('78)
to ASA's Recommended Plan ('78)

ITEM	EXPLANATION	NET CHANGE
I. FEDERAL		
A. BIG DRY CREEK DAM		
03. RESERVOIRS	The net decrease of $70,000 is due primarily to a reduction in the scope and area of the clearing requirement.	-$ 70,000
04. DAMS	The net decrease of $4,734,000 is due primarily to a) Main Dam (-$3,646,000) redesign, reflecting a decrease in the embankment height, b) Spillway (+$151,000) increased width and preparation of a more detailed cost estimate, c) Little Dry Creek Outlet Works (-$488,000) redesign, and preparation of a more detailed quantity estimate, and d) Big Dry Creek Outlet works (-$751,000) redesign, and preparation of a more detailed quantity estimate.	-$4,734,000
09. CHANNELS AND CANALS	The net decrease of $122,000 is due to redesign and reduction in requirements for this item.	-$ 122,000
14. RECREATION	The net decrease of $950,000 is due to deletion of recreation as a project purpose.	-$ 950,000
19. BUILDINGS, GROUNDS, AND UTILITIES	The net increase of $12,000 is due to re-evaluation of requirements for this item.	+$ 12,000

Table 36 (Continued)

ITEM		EXPLANATION	NET CHANGE
FEDERAL (continued)			
20.	PERMANENT OPERATING EQUIPMENT	The net decrease of $14,000 is due to re-evaluation of requirements for this item.	-$ 14,000
30.	ENGINEERING AND DESIGN	The net decrease of $872,000 is due to the overall reduction of direct cost of the project due to eliminating the recreation function.	-$ 872,000
31.	SUPERVISION AND ADMINISTRATION	The net decrease of $830,000 is due to the overall reduction of direct cost of the project due to eliminating recreation.	-$ 830,000
B.	FANCHER CREEK DAM		
03.	RESERVOIRS	The net decrease of $160,000 is due primarily to a reduction in the area requiring clearing due to change in reservoir size from 200 year to 100 year level of protection.	-$ 160,000
04.	DAMS	The net decrease of $5,422,000 is due primarily to; reduction in size of the embankment (-$5,287,000); and a reduction in the concrete requirements for the spillway and outlet works (-$135,000) due to changing the reservoir size from 200 year to 100 year level of protection.	-$5,422,000
08.	ROADS	The net increase of $8,000 is due to the required rerouting due to change in size of the parabolic drop and stilling basin.	+$ 8,000
19.	BUILDING GROUNDS AND UTILITIES	The net decrease of $80,000 is due to the deletion of this item as not required.	-$ 80,000
20.	PERMANENT OPERATING EQUIPMENT	The net increase of $4,000 is due to revised hydrologic requirements in data collection.	+$ 4,000

Cost Estimates

Table 36 (Continued)

ITEM		EXPLANATION	NET CHANGE
FEDERAL (continued)			
30.	ENGINEERING AND DESIGN	The net decrease of $873,000 is due primarily to the reduction in direct cost caused by a reduction in level of flood protection from 200 year to 100 year.	-$ 873,000
31.	SUPERVISION AND ADMINISTRATION	The net decrease of $777,000 is due primarily to the reduction in direct cost caused by a reduction in level of flood protection from 200 year to 100 year.	-$ 777,000
C.	REDBANK CREEK DETENTION BASIN		
03.	RESERVOIRS	The net increase of $14,000 is due primarily to more detailed quantity estimate, adding a moderate reservoir clearing requirement.	+$ 14,000
04.	DAMS	The net decrease of $363,000 is due primarily to reduction in size of the excavation due to changing the level of protection from 200-year to 100-year.	-$ 363,000
20.	PERMANENT OPERATING EQUIPMENT	The net increase of $1,000 is due to re-evaluation of requirements which resulted from refining the system operation plan.	+$ 1,000
30.	ENGINEERING AND DESIGN	The net decrease of $121,000 is due primarily to the reduction in direct cost caused by a reduction in the level of flood protection from 200 year to 100 year.	-$ 121,000
31.	SUPERVISION AND ADMINISTRATION	The net decrease of $211,000 is due primarily to the reduction in direct cost caused by a reduction in the level of flood protection from a 200 year to a 100 year.	-$ 211,000

Table 36 (Continued)

ITEM	EXPLANATION	NET CHANGE
II. NON-FEDERAL		
A. BIG DRY CREEK DAM		
LANDS AND DAMAGES:	The decrease of $863,000 is due to a reduction in the real estate requirements which resulted from elimination of the recreation purpose.	-$ 863,000
RELOCATIONS:	The decrease of $217,000 is due to a change in the scope of the type of utilities requiring relocation.	-$ 217,000
B. FANCHER CREEK DAM		
LANDS AND DAMAGES:	The net decrease of $2,298,000 is due to a more detailed quantity estimate breakdown and reduced reservoir size.	-$2,298,000
RELOCATIONS:	The net increase of $98,000 is due to repricing.	+$ 98,000
C. REDBANK CREEK DETENTION BASIN		
LANDS AND DAMAGES:	The net increase of $380,000 is due to a more detailed quantity estimate breakdown and reduced detention basin size.	+$ 380,000

b. Price Level Changes. - Changes in first cost from the ASA's Recommended Plan (1 Oct 78) to the ASA's Recommended Plan (1 Oct 85) are due entirely to price level escalations. These changes are shown in Table 35.

c. ASA's Recommended ('85) Plan and Selected Plan ('85). - The reasons for changes in costs between the Recommended Plan (1 Oct 85) and the Selected Plan (1 Oct 85) are presented below in Table 37. The net changes in cost for the items shown in Table 37 are due primarily to changes in design, repricing, and reduction of contingencies from 25% to 15%, using guidance in EM 1110-2-1301 (Cost Estimates-Planning and Design Stages, 31 July 1980).

Table 37

Explanation of Cost Changes from ASA's Recommended Plan ('85) to Selected Plan ('85)

ITEM		EXPLANATION	NET CHANGE
I.	FEDERAL		
A.	BIG DRY CREEK DAM		
03.	RESERVOIRS	The net decrease of $220,000 is due primarily to repricing and a reduction of the contingencies from 25% to 15%.	-$ 220,000
04.	DAMS	The net decrease of $1,370,000 is due primarily to a reduction in the contingencies from 25 to 15%.	-$1,370,000
09.	CHANNELS AND CANALS	The net decrease of $5,000 is due to a reduction of contingencies from 25% to 15%.	-$ 5,000
11.	LEVEES AND FLOODWALLS	The net increase of $370,000 is due to including this feature after the flood plain was updated.	+$ 370,000
20.	PERMANENT OPERATING EQUIPMENT	The net decrease of $20,000 is due to a reduction of contingencies from 25% to 15%.	-$ 20,000
30.	ENGINEERING AND DESIGN	The net decrease of $110,000 is due to the overall reduction of direct cost of the project due to scope and contingencies changes.	-$ 110,000

Table 37 (continued)

ITEM	EXPLANATION	NET CHANGE
FEDERAL (continued)		
31. SUPERVISION AND ADMINISTRATION	The net decrease of $145,000 is due to the overall reduction of direct cost of the project due to scope and contingencies changes.	-$ 145,000
B. FANCHER CREEK DAM		
03. RESERVOIRS	The net decrease of $30,000 is due primarily to a reduction in scope of the required clearing, repricing of the remaining work and a reduction of the contingencies from 25% to 15%.	-$ 30,000
04. DAMS	The net decrease of $510,000 is due primarily to: a) main dam; (-$60,000) due primarily to developing a more detailed quantity estimate, repricing the remaining work and a reduction in the contingencies from 25% to 15%, b) spillway and outlet works; (-$450,000) due primarily to redesign, preparation of a more detailed quantity estimate, and a reduction of contingencies from 25% to 15%.	-$ 510,000
08. ROADS	The net decrease is due to reduction of contingencies from 25% to 15%.	-$ 10,000
20. PERMANENT OPERATING EQUIPMENT	The net decrease of $5,000 is due to re-evaluation of requirements and a reduction of the contingencies from 25% to 15%.	-$ 5,000
30. ENGINEERING AND DESIGN	The net decrease of $100,000 is due primarily to the reduction in direct cost caused by a reduction in size of project, repricing, and a reduction of contingencies from 25% to 15%.	-$ 100,000

Table 37 (continued)

ITEM		EXPLANATION	NET CHANGE
FEDERAL (continued)			
31.	SUPERVISION AND ADMINISTRATION	The net decrease of $45,000 is due primarily to the reduction in direct cost caused by repricing, and a reduction of contingencies from 25% to 15%.	-$ 45,000
	C. PUP CREEK DETENTION BASIN		
03.	RESERVOIRS	The net decrease of $4,000 is due primarily to repricing, offset by a reduction in the contingencies from 25% to 15%.	-$ 4,000
04.	DAMS	The net increase of $2,991,000 is due primarily to; a) detention basin; (+$2,470,000) due to redesign, partially offset by a reduction in contingencies from 25% to 15%; b) spillway; (-$111,000) due to the deletion of the feature; c) outlet works; (+$632,000) due to redesign and inclusion of exit channel work partially offset by a reduction in contingencies from 25% to 15%.	+$2,991,000
20.	PERMANENT OPERATING EQUIPMENT	The net increase of $7,000 is due to repricing, partially offset by a reduction in contingencies from 25% to 15%.	+$ 7,000
30.	ENGINEERING AND DESIGN	The net increase of $326,000 is due primarily to increased direct cost due to redesign, partially offset by a reduction in contingencies from 25% to 15%.	+$ 326,000
31.	SUPERVISION AND ADMINISTRATION	The net increase of $130,000 is due primarily to increased direct cost due to redesign, partially offset by a reduction in contingencies from 25% to 15%.	+$ 130,000

Table 37 (continued)

ITEM	EXPLANATION	NET CHANGE
FEDERAL (continued)		
D. ALLUVIAL DRAIN DETENTION BASIN:		
03. RESERVOIRS	The net decrease of $4,000 is due primarily to repricing, offset by a reduction in the contingencies from 25% to 15%.	-$ 4,000
04. DAMS	The net increase of $2,046,000 is due primarily to; a) detention basin; (+$2,296,000) due to a change in design, partially offset by a reduction in contingencies from 25% to 15%; b) spillway; (-$470,000) due to the deletion of the feature; c) outlet works; (+$220,000) due to redesign, partially offset by a reduction in contingencies from 25% to 15%.	+$2,046,000
20. PERMANENT OPERATING EQUIPMENT	The net increase of $5,000 is due to repricing, partially offset by a reduction in contingencies from 25% to 15%.	+$ 5,000
30. ENGINEERING AND DESIGN	The net increase of $207,000 is due primarily to increased direct cost due to more detailed designs, partially offset by a reduction in contingencies from 25% to 15%.	+$ 207,000
31. SUPERVISION AND ADMINISTRATION	The net increase of $66,000 is due primarily to increased direct cost due to more detailed designs, partially offset by a reduction in contingencies from 25% to 15%.	+$ 66,000
E. REDBANK CREEK DETENTION BASIN:		
03. RESERVOIRS	The net decrease of $18,000 is due primarily to an increased scope of clearing requirements offset by a decrease in contingencies from 25% to 15%.	-$ 18,000

Cost Estimates

Table 37 (continued)

ITEM	EXPLANATION	NET CHANGE
FEDERAL (continued)		
04. DAMS	The net increase of $1,530,000 is due primarily to more detailed designs, partially offset by a decrease in contingencies from 25% to 15%.	+$1,530,000
30. ENGINEERING AND DESIGN	The net increase of $220,000 is due primarily to increased direct cost due to redesign, partially offset by a reduction in contingencies from 25% to 15%.	+$ 220,000
31. SUPERVISION AND ADMINISTRATION	The net increase of $68,000 is due primarily to increased direct cost due to redesign, partially offset by a reduction in contingencies from 25% to 15%.	+$ 68,000
F. CULTURAL RESOURCES	The net increase of $400,000 is due to development of a preliminary cultural resources mitigation plan.	+$ 400,000
G. CP&E FUNDS	Funds added as per DAEN-CWB Instruction dated 6 September 85	+$ 700,000
II. NON-FEDERAL		
A. BIG DRY CREEK DAM		
LANDS AND DAMAGES	The net increase of $560,000 is due to repricing based on a more detailed quantity estimate breakdown.	+$ 560,000
RELOCATIONS	The net decrease of $10,000 is due to repricing, offset by a reduction in contingencies from 25% to 15%.	-$ 10,000
B. FANCHER CREEK DAM		
LANDS AND DAMAGES	The net increase of $1,540,000 is due to repricing based on a more detailed quantity estimate breakdown.	+$1,540,000
RELOCATIONS	The net decrease of $10,000 is due to repricing, based on a more detailed quantity estimate breakdown.	-$ 10,000

Table 37 (continued)

ITEM	EXPLANATION	NET CHANGE
FEDERAL (continued)		
C. PUP CREEK DETENTION BASIN		
LANDS AND DAMAGES	The net decrease of $2,080,000 is due to repricing based on a more detailed quantity estimate breakdown.	-$2,080,000
D. ALLUVIAL DRAIN DETENTION BASIN		
LANDS AND DAMAGES	The net decrease of $150,000 is due to repricing based on a more detailed quantity estimate breakdown.	-$ 150,000

106. Basis of Annual Cost Estimate. - The estimate of annual cost for the selected plan is based on 1 October 1985 price levels, an 8-5/8 percent interest rate, and a 100 year amortization period, using guidance in SPK-EDM No. 46. Interest during construction was not calculated due to the nature of the construction - benefit sequence anticipated (2 year construction time). Annual charges include operation and maintenance costs which are based on costs experienced in the Sacramento District. The annual cost estimates do not include estimated costs for cultural resources mitigation in accordance with ER 1105-2-50 and EP 1105-2-55.

107. Detailed Summary of Annual Cost. - A detailed summary of annual cost by account for each feature and the total project is presented in Table 38. The investment cost is summarized in Table 28.

Table 38
Detailed Summary of Annual Costs by Account

	TOTAL ($)	BIG DRY ($)	FANCHER ($)	PUP ($)	ALLUVIAL ($)	REDBANK ($)	CULTURAL & CP&E ($)
FEDERAL:							
A INTEREST RATE........8.625%	4,248,700	1,060,900	1,436,800	353,600	284,700	1,052,300	60,400
B AMORTIZATION RATE: 0.00002	1,300	300	400	100	100	300	100
PERIOD IN YEARS:100							
C ADJ. FOR NET LOSS IN PRODUCTIVITY OF LANDS (TYPICALY NEGLIGIBLE)	0	0	0	0	0	0	0
D MAINTENANCE AND OPERATION	0	0	0	0	0	0	0
E REPLACEMENT COSTS	0	0	0	0	0	0	0
F TOTAL FEDERAL ANNUAL COST	4,250,000	1,061,200	1,437,200	353,700	284,800	1,052,600	60,500
NON-FEDERAL:							
A INTEREST RATE.......8.625%	901,800	172,500	470,500	60,400	43,100	155,300	0
B AMORTIZATION RATE: 0.00002	500	100	100	100	100	100	0
PERIOD IN YEARS:100							
C ADJ. FOR NET LOSS IN PRODUCTIVITY OF LANDS (TYPICALY NEGLIGIBLE)	0	0	0	0	0	0	0
D MAINTANCE AND OPERATION	224,250	135,200	53,500	4,100	3,350	28,100	0
RESERVOIRS	147,300	90,000	35,300	0	0	22,000	0
ROADS	8,925	4,050	4,400	125	350	0	0
CONCRETE	24,640	12,200	8,300	1,790	800	1,550	0
STEEL	4,035	3,500	400	10	25	100	0
GATES	12,350	8,750	0	0	0	3,600	0
UTILITIES AND MISC.	100	100	0	0	0	0	0
BUILDINGS, GROUNDS, AND UTILITIES	2,600	2,600	0	0	0	0	0
TURFED SLOPE PROTECTION	4,950	1,400	3,550	0	0		
MISC INSTRUMENTS	14,325	12,300	1,500	0	0	525	0
EXTRAORDINARY SEDIMENT REMOVAL	4,000	0	0	2,000	2,000	0	
EX-ORD. SED. REMOVAL (EXIT) PER YEAR	300	0	0	150	150	0	0
PROTECTIVE STONE	725	300	50	25	25	325	0
E REPLACEMENT COSTS	3,450	2,650	100	0	0	700	0
UTILITIES AND MISC.	25	25	0	0	0	0	0
BUILDINGS, GROUNDS, AND UTILITIES	200	200	0	0	0	0	0
GATES	2,175	1,525	0	0	0	650	0
MISC. INSTRUMENTS	1,050	900	100	0	0	50	0
F TOTAL NON-FEDERAL ANNUAL COST	1,130,000	310,450	524,200	64,600	46,550	184,200	0
TOTAL PROJECT ANNUAL COST	5,380,000	1,371,650	1,961,400	418,300	331,350	1,236,800	60,500

108. Introduction. - Economic justification of the Selected Plan was established by comparing the estimated equivalent average annual benefits with the estimated average annual costs. Average annual benefits and costs were based on a 100 year period of analysis beginning with 1990, the completion of construction, and ending with 2090 utilizing an 8-5/8 percent interest rate. Standard Corps of Engineers practices and procedures were used to develop the costs and benefits. Estimated costs include the value of material and services used in the initial construction of the project, converted into annual interest and amortization values, and annual operation, maintenance, and replacement costs. The annual costs and benefits were compared in a benefit-to-cost ratio to demonstrate project economic justification. The average annual benefits should equal or exceed the average annual costs if the Federal Government is to participate in the project.

The Feasibility Report, dated February 1979, is the basis for establishing the economic benefits associated with the Selected Plan. the benefits include flood damage reduction benefits and benefits realized from savings in flood proofing costs. Fresno County is no longer designated by the U.S. Department of Commerce as an area of substantial and persistent unemployment; therefore, the Redbank and Fancher Creeks projects is no longer eligible for National Economic Development employment benefits. Also, recreation is no longer a project purpose, as discussed in Chapter I - Introduction. Thus, the project does not yield recreation benefits. the economic criteria and projections used to obtain the benefit estimates encompass recent evaluation procedures contained in the Principles and Guidelines, the Flood Disaster Protection Act of 1973, and the Water Resources Development Act of 1974.

109. Average Annual Damages. -

a. Without the Project. - Estimated probable average annual flood damages without the proposed project were based on flood plains under existing conditions. Damages were estimated for the present year (1985), the base year (1990), and annually throughout the study period, 1990-2090. Average annual equivalent damages were estimated on the basis of 8-5/8 percent interest rate, 1 October 1985 prices, and standard discounting procedures. No growth was assumed in the flood plains after 2040. The effects of the National Flood Insurance program and affluence on residential contents also were evaluated in developing the flood damages. The estimated probable average annual equivalent damages for the without project conditions are $14,002,000. Table 40 presents the average annual equivalent damages for each stream group, without the project.

b. With the Project. - The estimated probable average annual residual flood damages were computed using the Los Angeles District Damages Program. These are the damages expected under the "with project" floodplain conditions. The total damages with the project are $6,057,000.

Economics of the Selected Plan

Table 39

Summary of Average Annual Equivalent Damages
Without the Project

Stream Group	Damages ($)
Big Dry Creek	$ 5,058,000
Fancher/Redbank Creeks	4,892,000
Pup Creek/Alluvial Drain	4,052,000
TOTAL	$14,002,000

110. Project Accomplishments. -

a. Big Dry Creek Flood Plain. - The proposed project would provide the Big Dry Creek flood plain below Big Dry Creek Dam and Diversion with complete protection from flood flows originating on Dry and Dog Creeks above the dam during a Standard Project Flood (SPF) event. However, residual damages will occur on Big Dry Creek from floods less frequent than the SPF (design flood) and from local runoff below the dam. This is because the value of damageable property is very large for those areas outside the SPF plain and because the project would have less effect on those flows that are more rare than the SPF. The project is expected to reduce the average annual without project damages experienced downstream of Big Dry Creek Dam, under existing conditions, by about 60 percent.

b. Redbank and Fancher Creeks and Pup Creek and Alluvial Drain Flood Plains. - The probable limits of residual flooding in the Redbank and Fancher Creeks, and Pup Creek and Alluvial Drain Flood Plains resulting from the SPF event are shown on Plate G2. This residual flooding would be of the shallow, sheet-flow, low-velocity type. Depths of inundation would range up to about 2.5 feet in the Redbank and Fancher Creeks flood plains, and up to about 3.5 feet in the Pup Creek and Alluvial Drain flood plains. These four project features would provide a 200-year level of protection immediately downstream from the facilities. Flood protection would decrease progressively in the downstream reaches due to the influence of local runoff and limited channel capacities. The project is expected to reduce the average annual without-project damages downstream of Pup Creek and Alluvial Drain areas, under existing conditions, by about 26 percent, and downstream of the Redbank and Fancher creeks area by almost 80 percent.

c. Flood Damage Reduction Benefits. - The flood damage reduction benefits for the Selected Plan are the difference between the equivalent average annual flood losses without the project and the residual average annual flood losses with the project.

d. Flood Proofing Benefits - When a project eliminates the need for flood proofing, the cost of such flood proofing, less any increase in residual damages, is a project benefit. To determine if discontinuation of flood proofing was economically rational, residual damages were estimated with and

without its implementation in conjunction with project construction. It would be economically irrational to continue flood proofing when its costs exceed the benefits as measured by the difference in residual damages. For all damage reaches within the Redbank and Fancher Creeks and Dry Creek flood plains, the increase in residual damages was less than the estimated cost of of the flood proofing programs. Flood proofing needed under the "without project" condition would, therefore, not be required after project construciton. Residual damages for the Redbank and Fancher Creeks and The Dry Creek flood plains were estimated assuming no flood proofing beyond 1990, with the flood proofing costs foregone identified as a project benefit. For estimating flood proofing costs, it was assumed that the first floor of all new and replacement structures within the 100-year flood plain would be elevated to the level of the 100-year flood plain in compliance with the Flood Disaster Protection Act of 1973. After the damages were derived, a local flood plain ordinance was put into effect, raising the minimum first floor elevation to six inches above the 100-year flood plain. The local ordinance was not in effect until 1979, after the economic inventory field surveys were completed. The estimates of residual damages included identifying the following impacts on flood proofing of future development:

(1) No further flood proofing would be accomplished beyond 1990 in the Redbank and Fancher Creeks area.

(2) No flood proofing would occur in the Big Dry Creek area beyond 1990, and

(3) No impact would be realized in the Pup Creek and Alluvial Drain areas because flood proofing, as assumed for the without project condition, would still be required.

111. Average Annual Flood Control Benefits. - The average annual flood control benefits and benefits attributed to savings in flood proofing costs are shown in Table 41.

Table 40

Summary of Average Annual Equivalent Flood Control Benefits

Stream(s)	Flood Damage Reduction	Savings in Flood Proofing	Total
	(x $1,000)	(x $1000)	(x $1000)
Big Dry Creek	3,019	208	3,227
Fancher/Redbank Creeks	3,869	322	4,191
Pup Creek/Alluvial Drain	1,057	--	1,057
TOTAL	7,945	530	8,475

Oct 85 price levels, 8-5/8% interest, 100 years

112. First and Annual Costs. - The estimated cost of the Selected Plan is summarized in Table 41. The estimate includes a breakdown of first cost for major items of the Selected Plan. The cost given is based on 1 October 1985

price levels. Prices used for major construction items were derived by adjustments of bids received in the Sacramento District and elsewhere for comparable work. Quantities of construction materials were based on the current design of project features. Continuation of Planning and Engineering (CP&E) costs of $700,000 incurred after FY-85, are included as per DAEN-CWB Instruction dated 6 September 1985. A 15 percent contingincy allowance and suitable allowances for engineering, design, supervision, and administration are included in the first cost in accordance with EM 1110-2-1301. A breakdown of this cost by project feature is shown in Chapter XV - Cost Estimates, Table 28.

Table 41

Summary of Estimated First Cost

Item	Cost ($)
Lands and Damages	10,100,000
Relocations	400,000
Dams and Reservoirs	41,064,000
Buildings, Grounds, and Utilities	50,000
Permanent Operating Equipment	235,000
Engineering and Design	4,680,000
Supervision and Administration	2,011,000
Cultural Resources	400
CP&E Funds	700
Total First Cost	$60,100,000

October 1985 Price Level

A summary of estimated annual costs is shown in Table 42. Interest during construction is not included because the construction period is estimated to be about 2 years or less for each feature and benefits will begin to accrue as soon as Pup Creek and Alluvial Drain Detention Basin are completed, at the end of the second project construction season. Interest on amortization charges are based on an 8-5/8 percent interest rate and reflect CP&E and cultural resources costs. The estimated cost of operation, maintenance, and major replacements are also included.

Table 42

Summary of Estimated Annual Costs

Item	Cost ($)
Interest	5,150,500
Amortization	1,800
Operation and Maintenance	224,250
Major Replacements	3,450
Total Annual Cost	5,380,000

Oct 1985 price levels, 8-5/8%, 100 years

Economics of the Selected Plan

113. Project Justification. - A comparison of the average annual benefits with the average annual costs for the selected plan of improvement is shown in the Table 43. For this comparison, the annual costs do not include costs for cultural resources mitigation in accordance with ER 1105-2-50 and EP 1105-2-55. Although intangible benefits may accrue to the national economy, only tangible primary benefits are represented in the tabulation. The project benefit-to-cost ratio is 1.6 to 1.

Table 43

Average Annual Costs and Benefits

Annual Costs	$5,380,000
Annual Benefits	$8,480,000
Excess Benefits	$3,100,000
Benefit-to-Cost Ratio	1.6 to 1

114. Introduction. - This chapter presents pertinent information regarding cost apportionment between Federal and non-Federal interests for the Selected Plan. Two cost apportionment methods are presented. The first is based on the traditional cost-sharing policies governing flood control projects. The second method is based on the currently proposed cost apportionment method.

115. Traditional Cost Apportionment. - Cost sharing by Federal and non-Federal interests for the selected plan is based on the standard requirements established as Federal policy for "local protection" works. Under this policy, contained in Section 3 of the 1936 Flood Control Act, non-Federal interests are required to furnish all lands, easements, and rights-of-way; accomplish all relocations and alterations; and bear all costs of operation and maintenance and replacement after completion of construction. The Federal Government will be responsible for all construction and cultural resources mitigation costs. The total cost of the proposed project is $60,100,000 which includes the $700,000 for CP&E efforts in FY-86 (as per DAEN-CWB Instructions). Table 44 shows the apportionment of the first cost and annual interest and amortization, operation and maintenance, and replacement costs between Federal and non-Federal interests, in accordance with the policy outlined above. A cost allocation was not necessary for the project because flood control is the only project purpose.

Table 44

Cost Apportionment
Traditional Method1/

Item	Federal ($)	Non-Federal ($)	Total ($)
First Cost			
Lands and Damages	-	10,100,000	10,100,000
Relocations	-	400,000	400,000
Construction	42,209,000	-	42,209,000
Engineering and Design1/	5,380,000	-	5,380,000
Supervision and Administration	2,011,000	-	2,011,000
Total	49,600,000	10,500,000	60,100,000
Annual Cost			
Interest and Amortization	4,250,000	902,300	5,152,300
Maintenance and Operation	-	224,250	224,250
Replacement	-	3,450	3,450
Total	4,250,000	1,130,000	5,380,000

Oct 85 price levels, 8-5/8%, 100 years
1/ Includes $700,000 CP&E costs

Cost Sharing and Local Cooperation Requirements

116. Traditional Project Responsibilities. -

a. Federal Responsibilities. - As indicated in Table 45, the estimated Federal share of the total first cost of the project is $49,600,000. Following completion of the Continuation of Planning and Engineering studies and authorization of the project by the Congress, the Federal Government would finalize designs, prepare detailed plans and specifications, and construct the project after funds are appropriated by the Congress and at least a local cooperation agreement between the project sponsor and the United States is signed.

b. Non-Federal Responsibilities. - Non-Federal interests would be responsible for the following:

(1) Provide all lands, easements, and rights-of-way for construction and maintenance of the project including all necessary relocations and alterations of buildings, roads, highways and highway bridges, sewers, and related utilities.

(2) Operate, maintain, and replace all project facilities after completion in accordance with regulations prescribed by the Secretary of the Army.

(3) Hold and save the United States free from damages due to the construction and operation of the project, not including damages due to the fault or negligence of the United States or its contractors.

(4) Prescribe and enforce regulations designated to prevent obstruction or encroachment of any type that would impair the flood control effectiveness of the work, and preserve or restore and thereafter maintain channels and diversion of flow structures required for conveyance of floodwaters within the project area to at least those capacities specified for the flood control system operation plan defined in this General Design Memorandum.

(5) Adjust all claims regarding water rights that might be affected by the flood control improvements.

117. Proposed Cost Apportionment. - The cost apportionment method presented in the following paragraphs is based on the Administration/Senate Majority Leadership cost sharing policy compromise as contained in S.1567 reported by the Senate Environment and Public Works Committee, 1 August 1985. This proposed policy, which revises the traditional method for sharing costs of Federal water projects between Federal and non-Federal interests, is intended to involve state and local interests more heavily in water project decisions and to eliminate many of the conflicting rules governing cost-sharing for flood control projects.

Based on the "Local Protection" classification of this project, non-Federal interests would be required to furnish a minimum of 25 percent of the total project costs excluding costs for cultural resources mitigation, in accordance with ER 1105-2-50 and EP 1105-2-55. The required non-Federal

share of project costs would be made up of a mandatory 5 percent cash contribution; all project lands, easements, rights-of-way, and relocations; and, if necessary, an additional cash contribution to bring the total non-Federal share to 25 percent of the total project costs including the $700,000 CP&E costs. The non-Federal contribution shall be made concurrently and proportionally with the Federal contractual obligation for project construction. Table 45 shows the apportionment of the first cost and annual interest and amortization, operation and maintenance, and replacement costs between Federal and non-Federal interests, in accordance with the policy outlined above.

Table 45

Cost Apportionment
Current Proposed Policy

Item	Federal ($)	Non-Federal ($)	Total ($)
First Cost			
5% Cash Contribution		2,980,000	2,980,000
Lands and Damages	-	10,100,000	10,100,000
Relocations	-	400,000	400,000
Additional Cash Contribution	-	1,440,000 1/	1,440,000
Construction	38,490,000	-	38,490,000
Engineering and Design	4,680,000	-	4,680,000
Supervision and Administration	2,010,000	-	2,010,000
Total	45,180,000	14,920,000	60,100,000
Annual Cost			
Interest and Amortization	4,110,000	1,042,300	5,152,300
Operation and Maintenance	-	224,250	224,250
Replacement	-	3,450	3,450
TOTAL	4,110,000	1,270,000	5,380,000

Oct 85 price levels, 8-5/8%, 100 years

1/ Additional cash contribution required to bring non-Federal share of project cost to 25 percent; applied towards construction of project facilities.

Cost Sharing and Local Cooperation Requirements

118. Proposed Project Responsibilities. -

a. Federal Responsibilities. - As indicated in Table 45, the estimated Federal share of the total first cost of the project would be $45,180,000. Following completion of the Continuation of Planning and Engineering studies and authorization of the project by the Congress, the Federal Government would finalize designs, prepare detailed plans and specifications, and construct the project after funds are appropriated by the Congress and a local cooperation agreement between the project sponsor and the United States is signed.

b. Non-Federal Responsibilities. - Non-Federal interests would be responsible for the following:

(1) Contribute a mandatory 5 percent cash-share of the total first cost of the project.

(2) Provide all lands, easements, and rights-of-way for construction and maintenance of the project including all necessary relocations and alterations of buildings, roads, highways, and highway bridges, sewers, and related utilities.

(3) Contribute, if necessary, an additional cash-share to bring the total non-Federal contribution to 25 percent of the total project costs.

(4) Operate, maintain, and replace all project facilities after completion in accordance with regulations prescribed by the Secretary of the Army.

(5) Hold and save the United States free from damages due to the construction and operation of the project, not including damages due to the fault or negligence of the United States or its contractors.

(6) Prescribe and enforce regulations designated to prevent obstruction or encroachment of any type that would impair the flood control effectiveness of the work, and preserve or restore and thereafter maintain channels and diversion of flow structures required for conveyance of floodwaters within the project area to at least those capacities specified for the flood control system operation plan defined in this General Design Memorandum.

(7) Adjust all claims regarding water rights that might be affected by the flood control improvements.

(8) At lease annually inform affected interests regarding the limitations of the protection afforded by the project.

119. Comparison of Cost Apportionment Methods. - Table 46 shows a comparison of costs between the traditional and proposed cost-sharing methods.

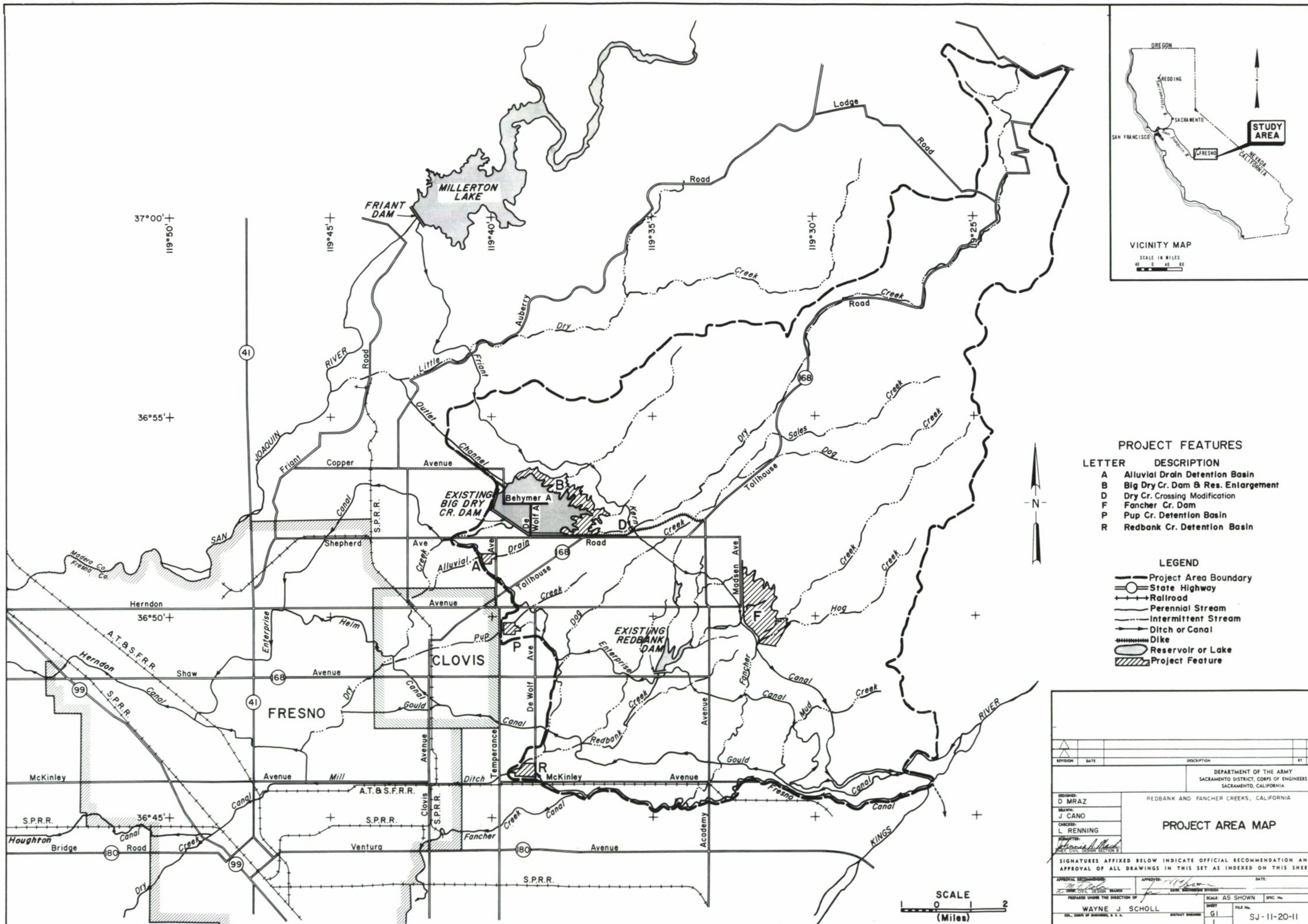
Table 46

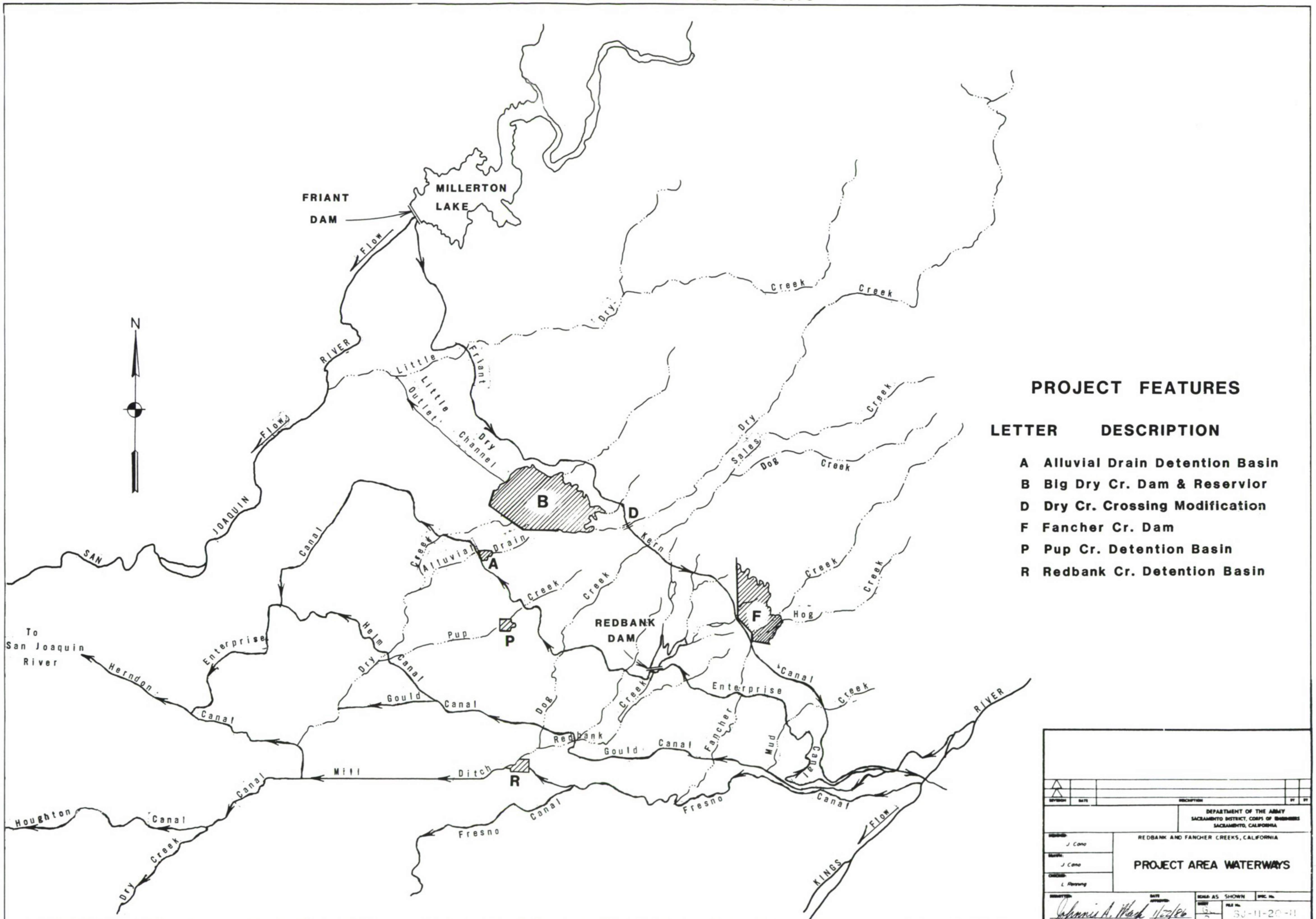
Comparison of Cost Apportionment Methods

Item	Federal ($)	Non-Federal ($)	Total ($)
First Cost			
Traditional	49,600,000	10,500,000	60,100,000
Proposed	45,180,000	14,920,000	60,100,000
Annual Cost			
Traditional	4,250,000	1,130,000	5,380,000
Proposed	4,110,000	1,270,000	5,380,000

Chapter XVIII - Recommendations

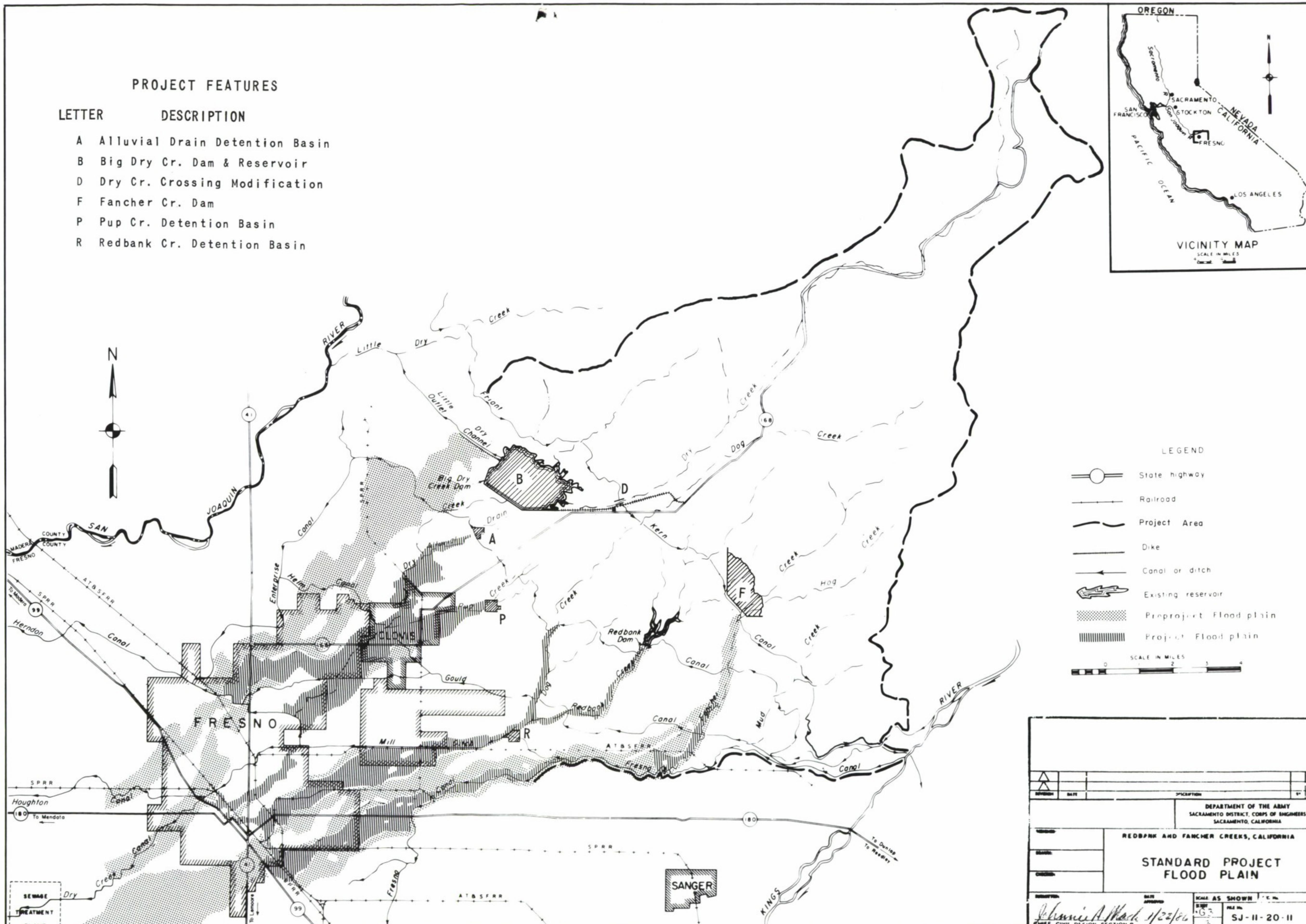
120. Recommendations. - It is recommended that this Design Memorandum and the Selected Plan to provide flood control on Dry Creek, Fancher Creek, Pup Creek, Redbank Creek, and Alluvial Drain, as presented herein, be approved as the basis for proceeding with detailed project design and construction in accordance with the currently proposed cost sharing policy presented in Chapter XVII - Cost Sharing and Local Cooperation Requirements.

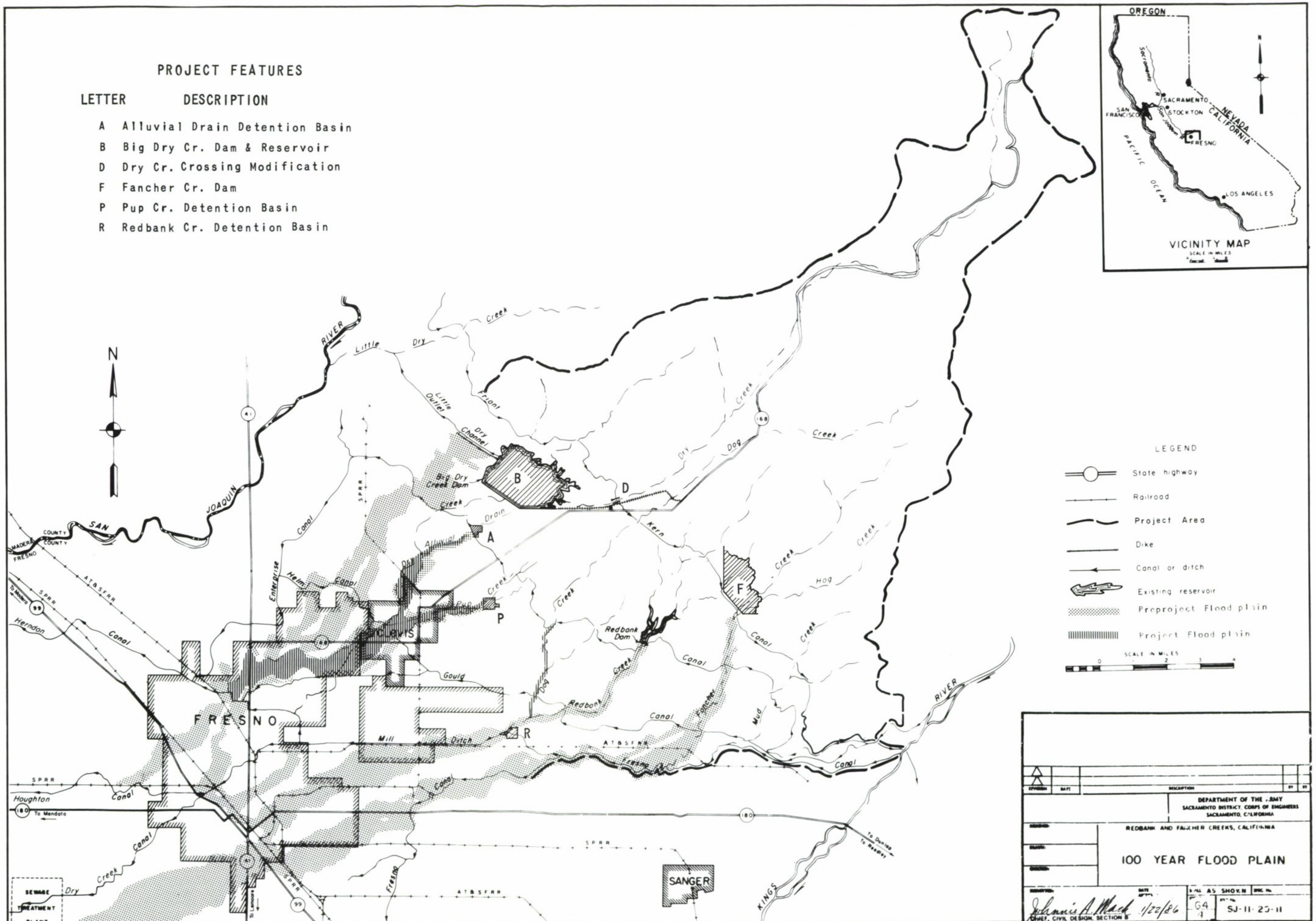

PROJECT FEATURES
LETTER DESCRIPTION
A Alluvial Drain Detention Basin
B Big Dry Cr. Dam & Res. Enlargement
D Dry Cr. Crossing Modification
F Fancher Cr. Dam
P Pup Cr. Detention Basin
R Redbank Cr. Detention Basin
LEGEND
Project Area Boundary
State Highway
Railroad
Perennial Stream
Intermittent Stream
Ditch or Canal
Dike
Reservoir or Lake
Project Feature
VICINITY MAP
STUDY AREA
OREGON
NEVADA
CALIFORNIA
REDDING
SACRAMENTO
SAN FRANCISCO
FRESNO
MILLERTON LAKE
FRIANT DAM
EXISTING BIG DRY CR. DAM
EXISTING REDBANK DAM
CLOVIS
FRESNO
SAN JOAQUIN RIVER
KINGS RIVER
SCALE 0 1 2 (Miles)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
REDBANK AND FANCHER CREEKS, CALIFORNIA
PROJECT AREA MAP
D MRAZ
J CANO
L RENNING
SIGNATURES AFFIXED BELOW INDICATE OFFICIAL RECOMMENDATION AND APPROVAL OF ALL DRAWINGS IN THIS SET AS INDEXED ON THIS SHEET
WAYNE J. SCHOLL
SCALE: AS SHOWN
G1
SJ-11-20-11

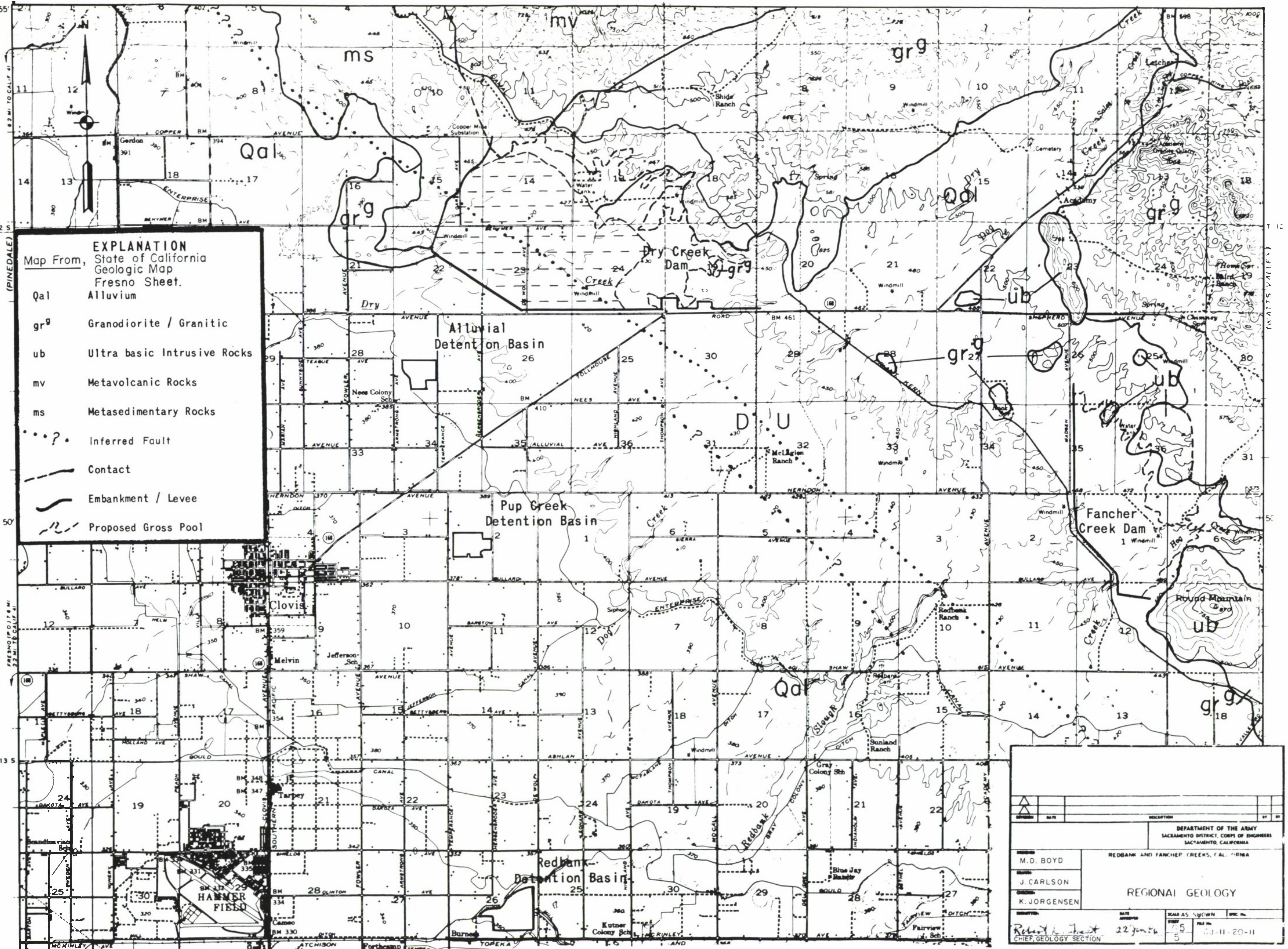


PROJECT FEATURES

LETTER	DESCRIPTION
A	Alluvial Drain Detention Basin
B	Big Dry Cr. Dam & Reservior
D	Dry Cr. Crossing Modification
F	Fancher Cr. Dam
P	Pup Cr. Detention Basin
R	Redbank Cr. Detention Basin


PROJECT FEATURES
LETTER DESCRIPTION
A Alluvial Drain Detention Basin
B Big Dry Cr. Dam & Reservoir
D Dry Cr. Crossing Modification
F Fancher Cr. Dam
P Pup Cr. Detention Basin
R Redbank Cr. Detention Basin
N
VICINITY MAP
OREGON
NEVADA
CALIFORNIA
SACRAMENTO
STOCKTON
SAN FRANCISCO
FRESNO
LOS ANGELES
PACIFIC OCEAN
LEGEND
State highway
Railroad
Project Area
Dike
Canal or ditch
Existing reservoir
Preproject Flood plain
Project Flood plain
SCALE IN MILES
FRESNO
CLOVIS
SANGER
SAN JOAQUIN RIVER
KINGS RIVER
Redbank Dam
Big Dry Creek Dam
SEWAGE TREATMENT PLANT
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
REDBANK AND FANCHER CREEKS, CALIFORNIA
STANDARD PROJECT FLOOD PLAIN
SCALE AS SHOWN
SJ-11-20-11
CHIEF, CIVIL DESIGN, SECTION B


PROJECT FEATURES
LETTER DESCRIPTION
A Alluvial Drain Detention Basin
B Big Dry Cr. Dam & Reservoir
D Dry Cr. Crossing Modification
F Fancher Cr. Dam
P Pup Cr. Detention Basin
R Redbank Cr. Detention Basin
LEGEND
State highway
Railroad
Project Area
Dike
Canal or ditch
Existing reservoir
Preproject Flood plain
Project Flood plain
SCALE IN MILES
VICINITY MAP
OREGON
NEVADA
CALIFORNIA
SACRAMENTO
STOCKTON
SAN FRANCISCO
FRESNO
LOS ANGELES
PACIFIC OCEAN
FRESNO
CLOVIS
SANGER
SAN JOAQUIN RIVER
KINGS RIVER
SEWAGE TREATMENT PLANT
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
REDBANK AND FANCHER CREEKS, CALIFORNIA
100 YEAR FLOOD PLAIN
AS SHOWN
1/22/86
SJ-11-23-11
CHIEF, CIVIL DESIGN SECTION B


EXPLANATION
Map From, State of California Geologic Map Fresno Sheet.
Qal Alluvium
gr^g Granodiorite / Granitic
ub Ultra basic Intrusive Rocks
mv Metavolcanic Rocks
ms Metasedimentary Rocks
Inferred Fault
Contact
Embankment / Levee
Proposed Gross Pool
Alluvial Detention Basin
Pup Creek Detention Basin
Redbank Detention Basin
Dry Creek Dam
Fancher Creek Dam
Round Mountain
Clovis
Melvin
HAMMER FIELD
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
REDBANK AND FANCHER CREEKS, CALIFORNIA
REGIONAL GEOLOGY
M.D. BOYD
J. CARLSON
K. JORGENSEN
CHIEF, GEOLOGY SECTION
SCALE AS SHOWN
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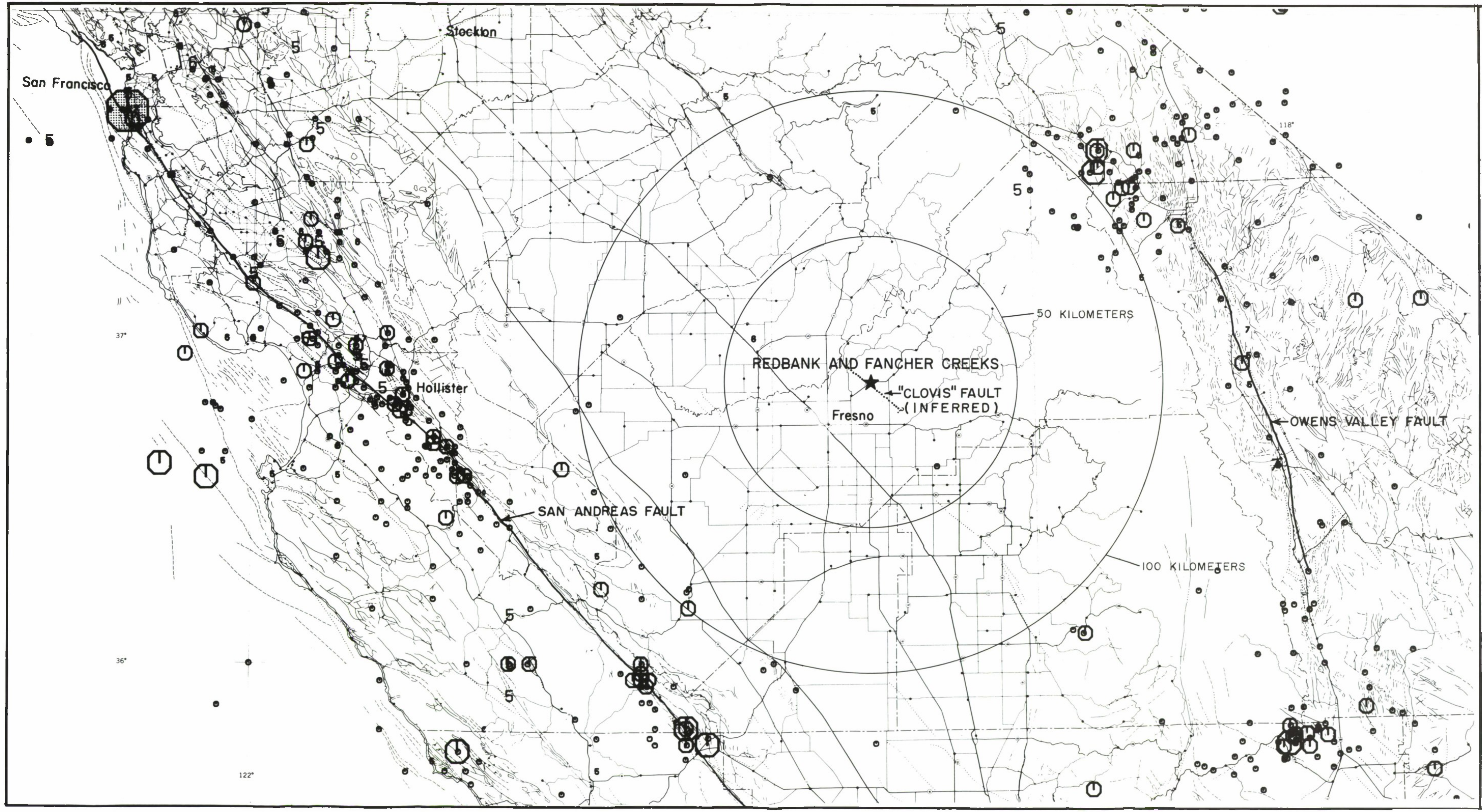

EXPLANATION

N

MAGNITUDE

....	4.0 TO 4.9
....	5.0 TO 5.9
....	6.0 TO 6.9
....	7.0 TO 7.9
....	8.0 OR GREATER

INTEGER.........MAXIMUM REPORTED INTENSITY

Fault

○5 — Digit indicates the number of earthquakes at the same location.

NOTE:
Only the larger of overlapping events are shown.

SOURCE: Earthquake Epicenter Map of California 1900 Through 1974
California Division of Mines and Geology Map Sheet 39, 1978 Edition

0 10 20 30 MILES

0 10 20 30 40 KILOMETERS

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

REDBANK AND FANCHER CREEKS, CALIFORNIA
BIG DRY CREEK

FAULTS AND EARTHQUAKE EPICENTERS

D. PAIGE
K. JORGENSEN

Robert L. Fuest 22 Jan 86
CHIEF, GEOLOGY SECTION

AS SHOWN
G6
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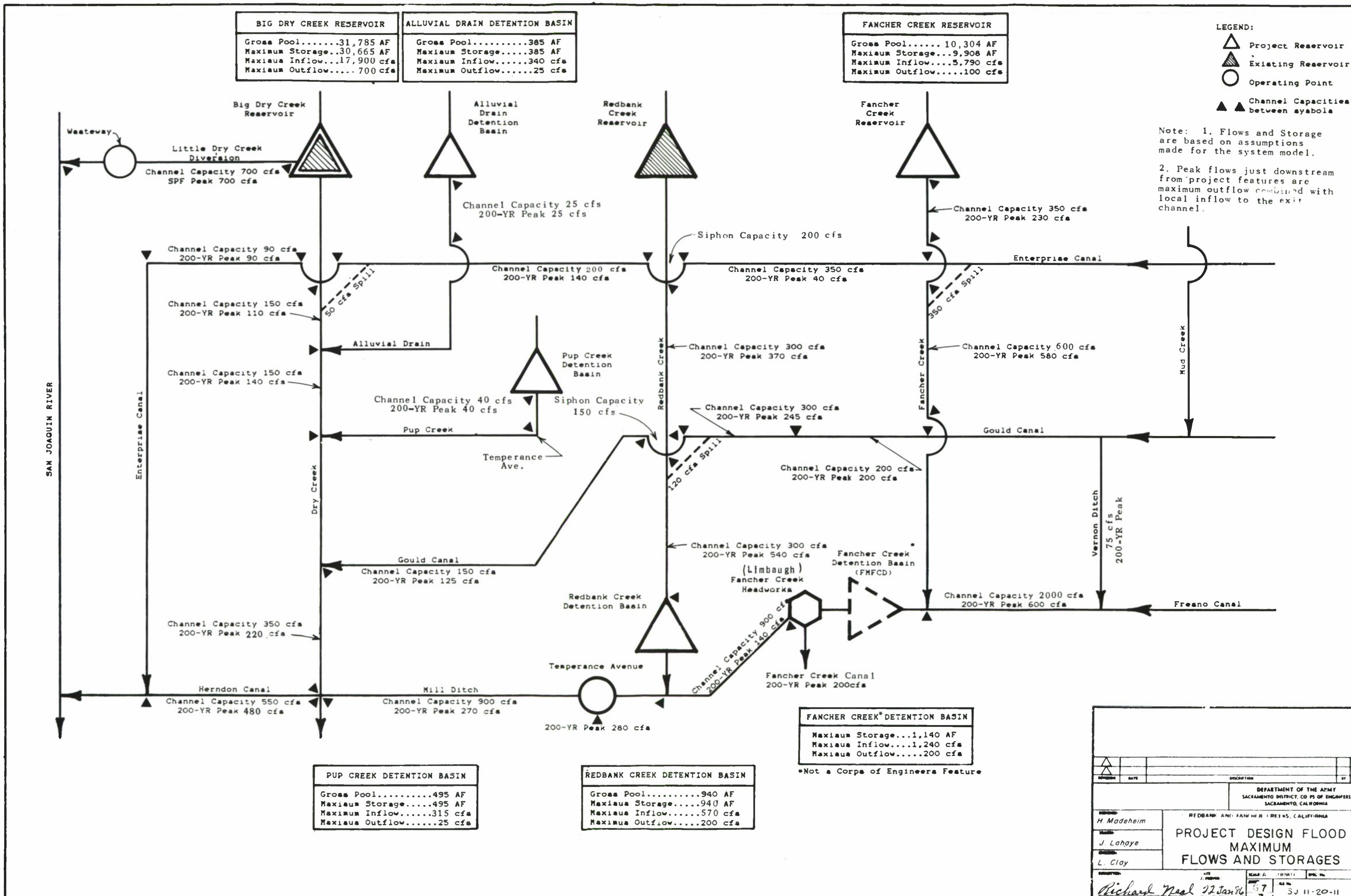
SJ-11-20-11


BIG DRY CREEK RESERVOIR
Gross Pool.......31,785 AF
Maximum Storage..30,665 AF
Maximum Inflow...17,900 cfs
Maximum Outflow..... 700 cfs
ALLUVIAL DRAIN DETENTION BASIN
Gross Pool.........385 AF
Maximum Storage.....385 AF
Maximum Inflow......340 cfs
Maximum Outflow......25 cfs
FANCHER CREEK RESERVOIR
Gross Pool...... 10,304 AF
Maximum Storage...9,908 AF
Maximum Inflow....5,790 cfs
Maximum Outflow.....100 cfs
LEGEND:
Project Reservoir
Existing Reservoir
Operating Point
Channel Capacities between symbols
Note: 1. Flows and Storage are based on assumptions made for the system model.
2. Peak flows just downstream from project features are maximum outflow combined with local inflow to the exit channel.
Big Dry Creek Reservoir
Alluvial Drain Detention Basin
Redbank Creek Reservoir
Fancher Creek Reservoir
Wasteway
Little Dry Creek Diversion
Channel Capacity 700 cfs
SPF Peak 700 cfs
Channel Capacity 25 cfs
200-YR Peak 25 cfs
Siphon Capacity 200 cfs
Channel Capacity 350 cfs
200-YR Peak 230 cfs
Channel Capacity 90 cfs
200-YR Peak 90 cfs
Channel Capacity 200 cfs
200-YR Peak 140 cfs
Channel Capacity 350 cfs
200-YR Peak 40 cfs
Enterprise Canal
50 cfs Spill
350 cfs Spill
Channel Capacity 150 cfs
200-YR Peak 110 cfs
Alluvial Drain
Channel Capacity 300 cfs
200-YR Peak 370 cfs
Channel Capacity 600 cfs
200-YR Peak 580 cfs
Mud Creek
Pup Creek Detention Basin
Channel Capacity 150 cfs
200-YR Peak 140 cfs
Redbank Creek
Fancher Creek
SAN JOAQUIN RIVER
Enterprise Canal
Channel Capacity 40 cfs
200-YR Peak 40 cfs
Siphon Capacity 150 cfs
Channel Capacity 300 cfs
200-YR Peak 245 cfs
Pup Creek
Gould Canal
Temperance Ave.
120 cfs Spill
Channel Capacity 200 cfs
200-YR Peak 200 cfs
Dry Creek
Vernon Ditch
75 cfs
200-YR Peak
Channel Capacity 300 cfs
200-YR Peak 540 cfs
Fancher Creek* Detention Basin (FMFCD)
Gould Canal
Channel Capacity 150 cfs
200-YR Peak 125 cfs
(Limbaugh)
Fancher Creek Headworks
Redbank Creek Detention Basin
Channel Capacity 2000 cfs
200-YR Peak 600 cfs
Fresno Canal
Channel Capacity 350 cfs
200-YR Peak 220 cfs
Channel Capacity 900 cfs
200-YR Peak 140 cfs
Temperance Avenue
Fancher Creek Canal
200-YR Peak 200cfs
Herndon Canal
Channel Capacity 550 cfs
200-YR Peak 480 cfs
Mill Ditch
Channel Capacity 900 cfs
200-YR Peak 270 cfs
200-YR Peak 280 cfs
FANCHER CREEK* DETENTION BASIN
Maximum Storage...1,140 AF
Maximum Inflow....1,240 cfs
Maximum Outflow.....200 cfs
*Not a Corps of Engineers Feature
PUP CREEK DETENTION BASIN
Gross Pool.........495 AF
Maximum Storage.....495 AF
Maximum Inflow......315 cfs
Maximum Outflow......25 cfs
REDBANK CREEK DETENTION BASIN
Gross Pool.........940 AF
Maximum Storage.....940 AF
Maximum Inflow......570 cfs
Maximum Outflow.....200 cfs
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
REDBANK AND FANCHER CREEKS, CALIFORNIA
H Madeheim
J. Lahaye
L. Clay
PROJECT DESIGN FLOOD
MAXIMUM
FLOWS AND STORAGES
Richard Neal 22 Jan 86
CHIEF, RESERVOIR CONTROL SECTION
7
SJ 11-20-11

REDBANK AND FANCHER CREEKS, CALIFORNIA

	FY-85	FY-86	FIRST CONSTRUCTION SEASON	SECOND CONSTRUCTION SEASON	THIRD CONSTRUCTION SEASON	FOURTH CONSTRUCTION SEASON
FUNDING REQUIREMENTS	$ 900,000 (C.P & E.)	$ 700,000 (C.P & E.)	$ 4,480,000 (CONSTRUCTION)	$24,700,000 (CONSTRUCTION)	$ 24,000,000 (CONSTRUCTION)	$6,220,000 (CONSTRUCTION)
BIG DRY CREEK DAM	FDM $ 93,000 GEOLOGY DM $ 22,200	FDM $ 212,100 GEOLOGY DM $ 21,000	PLANS AND SPECS. $ 298,000	PLANS AND SPECS. $60,000 CONSTRUCTION (16 MONTHS) $ 2,000,000	CONSTRUCTION (16 MONTHS) $ 8,040,000	$ 1,480,000
FANCHER CREEK DAM	FDM $ 52,800 GEOLOGY DM $ 7,300	FDM $ 202,400 GEOLOGY DM $ 20,100	PLANS AND SPECS $ 372,000	PLANS AND SPECS $ 80,000 CONSTRUCTION (18 MONTHS) $ 5,310,000	CONSTRUCTION (18 MONTHS) $ 6,660,000	$ 4,190,000
3 DETENTION BASINS	FDM $ 72,200 GEOLOGY DM $ 1,300	FDM $ 205,300 GEOLOGY DM $ 17,800	PLANS AND SPECS $ 399,000	PLANS AND SPECS $100,000 CONSTRUCTION (8 MOS.) PUP CREEK D.B. $ 2,240,000 ALLUVIAL DRAIN D.B. $ 2,650,000 REDBANK CREEK D.B. CONSTRUCTION (17 MOS.) $ 4,350,000	PUP CREEK D.B. $ 1,740,000 ALLUVIAL DRAIN D.B. $ 570,000 REDBANK CREEK D.B. CONSTRUCTION (17 MOS.) $ 6,990,000	$ 550,000
CONCRETE MATERIALS	CONCRETE MATERIAL DM $ 59,200	$ 18,300				
GENERAL DESIGN MEMORANDUM	FINALIZE GDM $ 592,000	APPROVAL				
COST SHARING AND LOCAL REQUIREMENTS		NEGOIATE AND APPROVE 221 AGREEMENT	EXECUITE LANDS, EASEMENTS, RIGHTS-OF-WAY, RELOCATION REQUIREMENTS $ 2,590,000	$ 7,910,000		
CULTURAL RESOURCES		MITIGATION PLAN $ 2,600	PLANS & SPECS CONSTRUCTION $ 400,000			
DRY CREEK SIPHON	(FDM WORK UNDER BIG DRY CREEK DAM)		PLANS & SPECS CONSTRUCTION $421,000			

RECEIVE CONGRESSIONAL AUTHORIZATION AND CONSTRUCTION FUNDING

NOTE
1. CONSTRUCTION FUNDS INCLUDE ALL FEDERAL AND NON-FEDERAL COSTS.
2. COSTS ARE BASED ON 1 OCTOBER 1985 PRICE LEVEL.

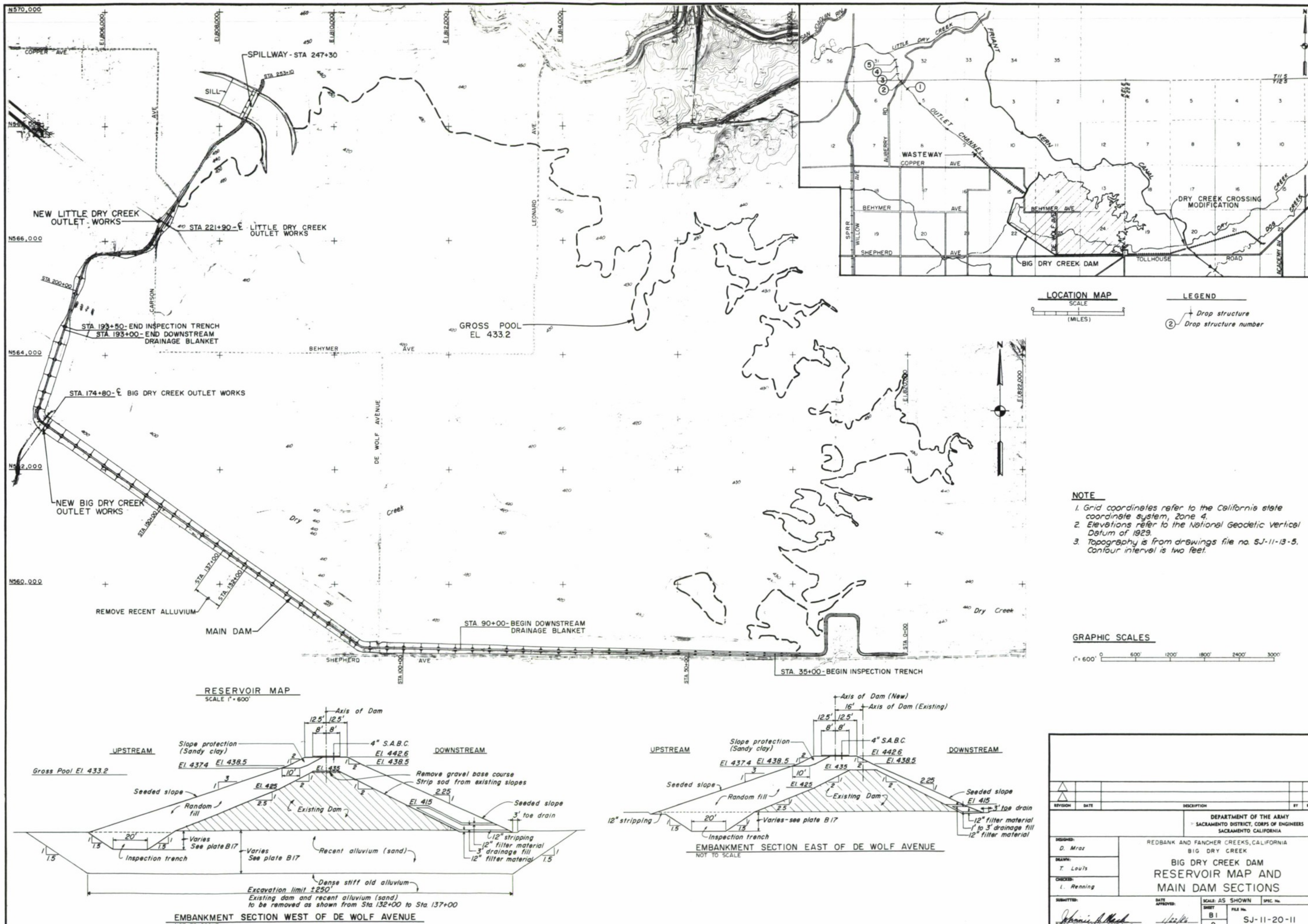
REVISION	DATE	DESCRIPTION	BY	BY

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DESIGNED: L. Reming
DRAWN: T. Louis
CHECKED: L. Renning
SUBMITTED: [signature] CHIEF, CIVIL DESIGN SECTION B

REDBANK AND FANCHER CREEKS, CALIFORNIA
DESIGN AND CONSTRUCTION SCHEDULE

DATE APPROVED: 4/22/86
SCALE: NONE
SHEET G8 8
SPEC. No.
FILE No. SJ-11-20-11



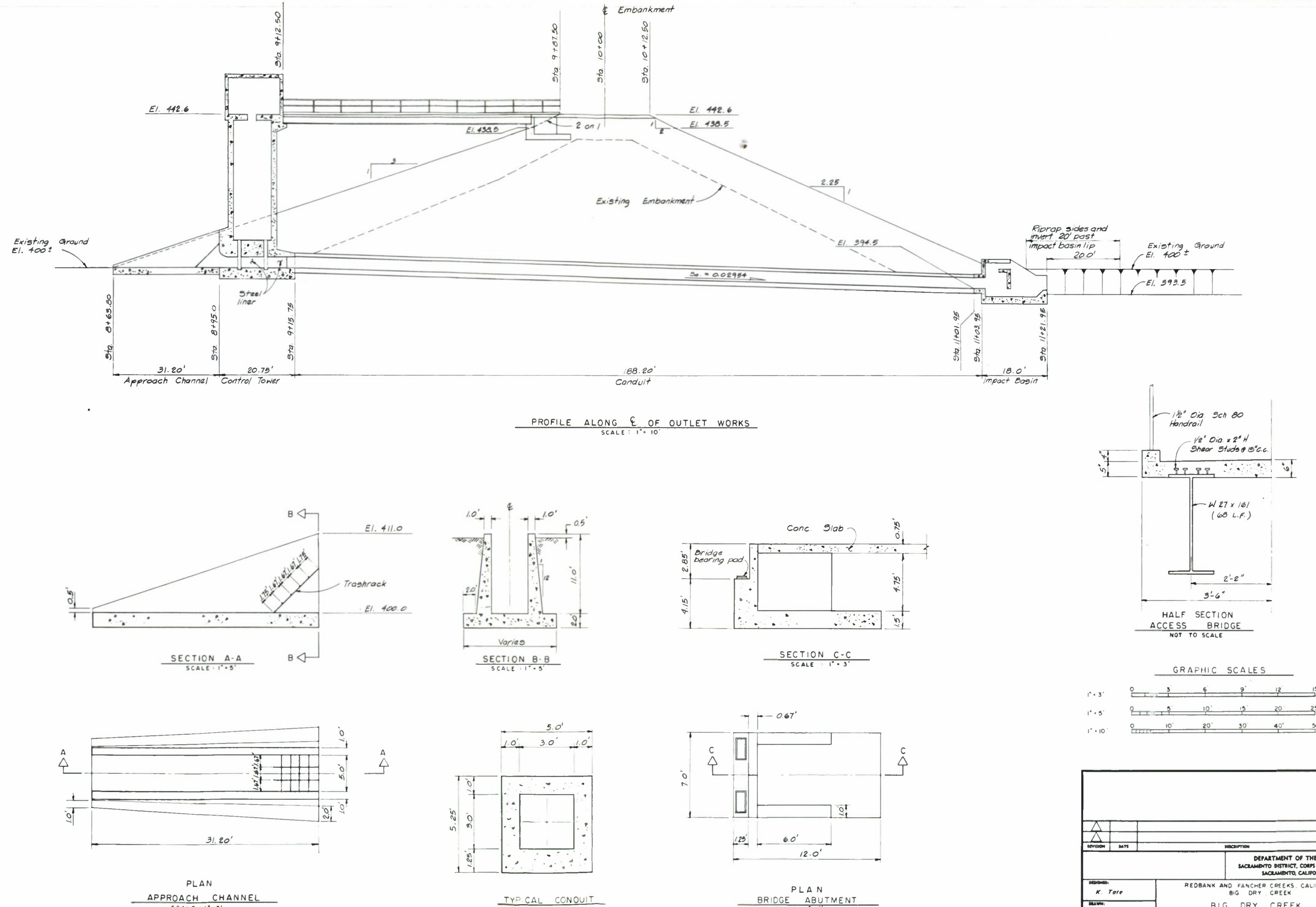
NOTE
1. Grid coordinates refer to the California state coordinate system, Zone 4.
2. Elevations refer to the National Geodetic Vertical Datum of 1929.
3. Topography is from drawings file no. SJ-11-13-5. Contour interval is two feet.

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO CALIFORNIA

REDBANK AND FANCHER CREEKS, CALIFORNIA
BIG DRY CREEK

BIG DRY CREEK DAM
RESERVOIR MAP AND
MAIN DAM SECTIONS

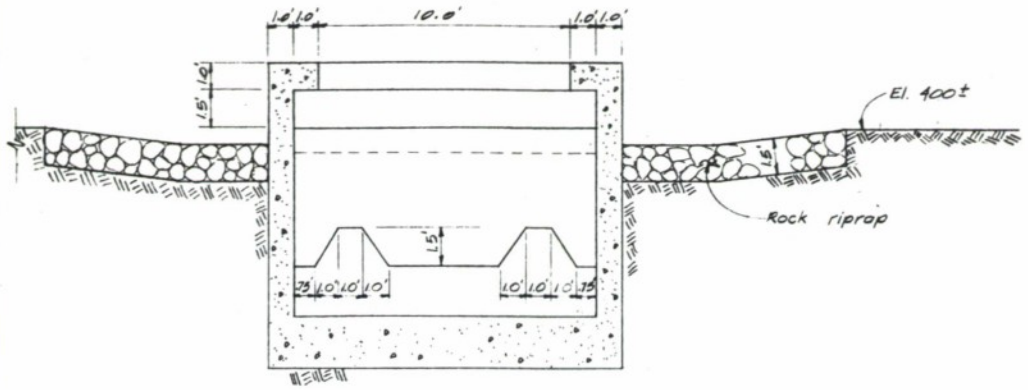
DESIGNED:	D. Mraz
DRAWN:	T. Louis
CHECKED:	L. Renning
SUBMITTED:	CHIEF, CIVIL DESIGN SECTION B
DATE APPROVED:	
SCALE:	AS SHOWN
SHEET	B1 9
FILE No.	SJ-11-20-11



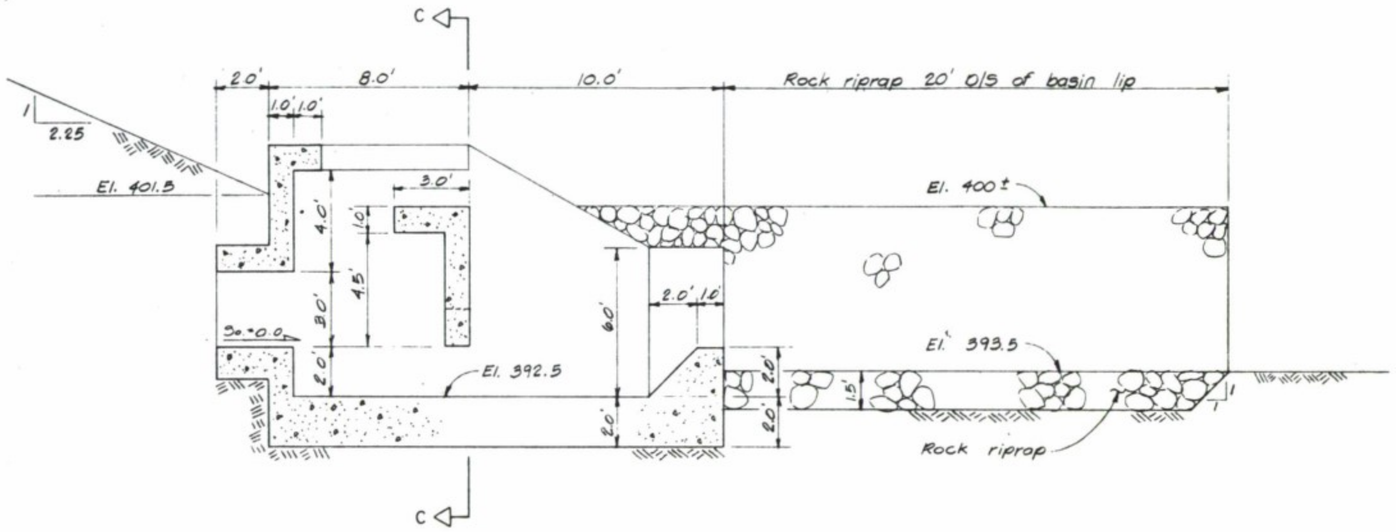
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

REDBANK AND FANCHER CREEKS, CALIFORNIA
BIG DRY CREEK
BIG DRY CREEK
OUTLET WORKS

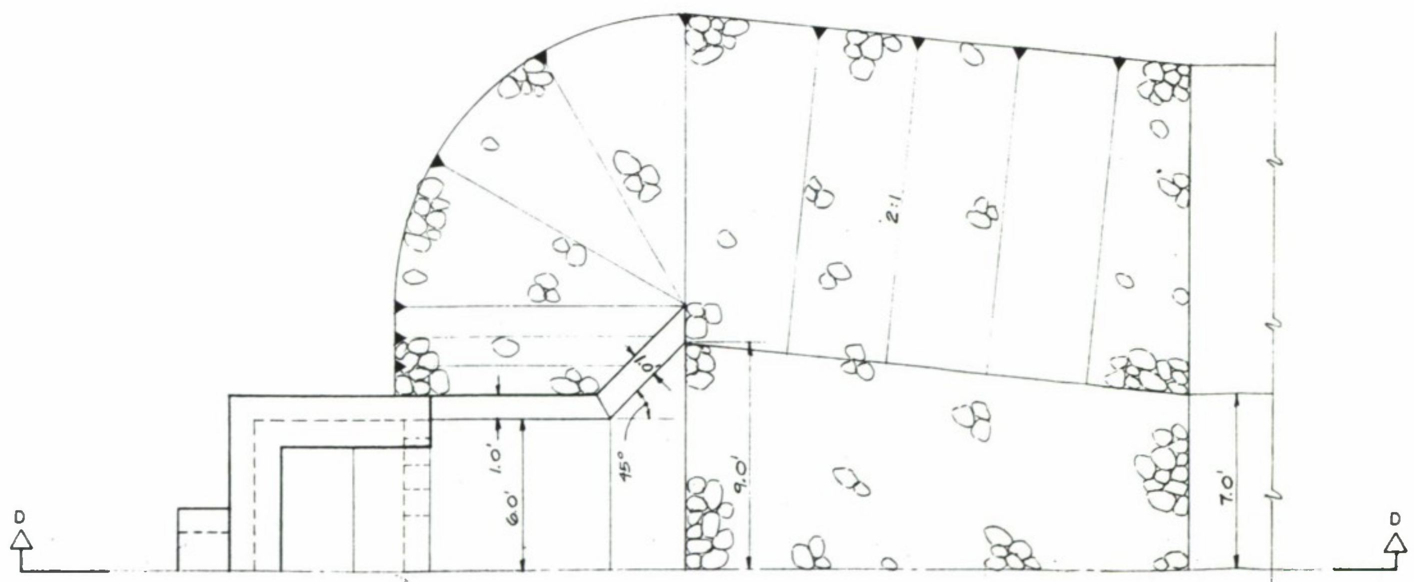
DESIGNED: K. Tate
DRAWN: G. Bucknell
CHECKED: L. Renning
SUBMITTED: Chief Civil Design Section B
SCALE: AS SHOWN
SHEET B2 10
SJ-11-20-11



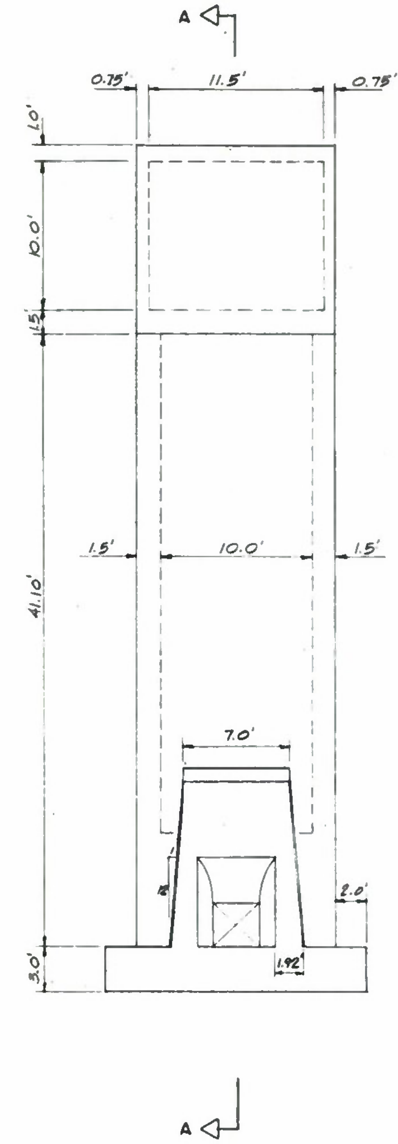
SECTION C-C
SCALE 1" = 3'



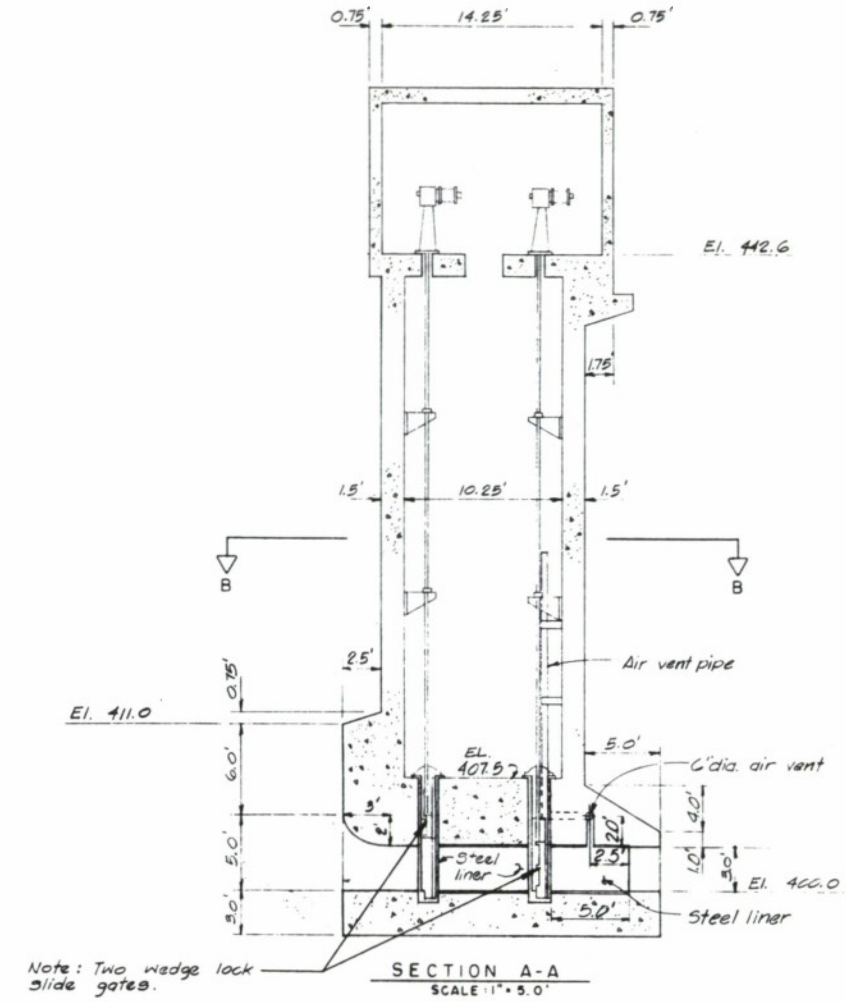
SECTION D-D
SCALE 1" = 3'



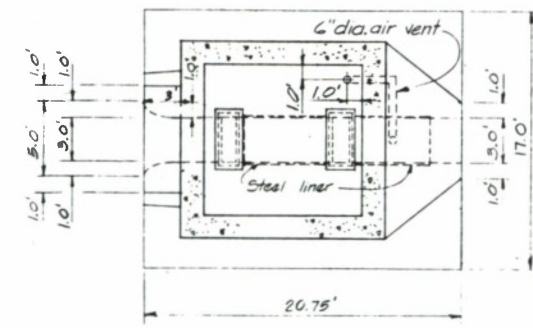
HALF PLAN IMPACT BASIN
SCALE: 1" = 3'



BIG DRY CK CONTROL TOWER
SCALE: 1" = 5'

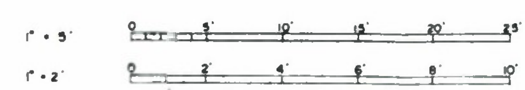


SECTION A-A
SCALE 1" = 5.0'



SECTION B-B
SCALE 1" = 5.0'

GRAPHIC SCALES



REVISION	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DESIGNED: K Toie
DRAWN: G Bucknell
CHECKED: L Renning
SUBMITTED:

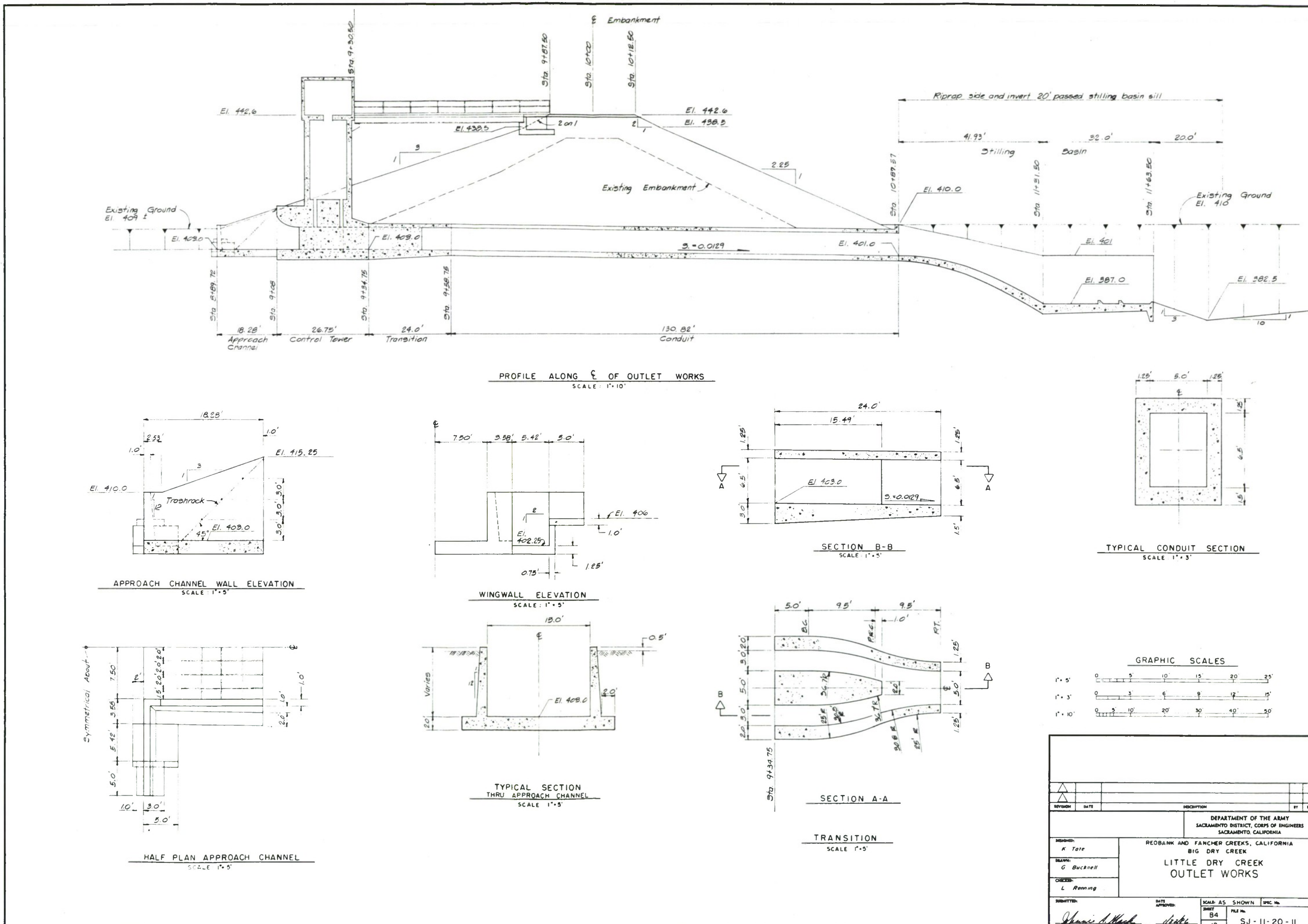
REDBANK AND FANCHER CREEKS, CALIFORNIA
BIG DRY CREEK

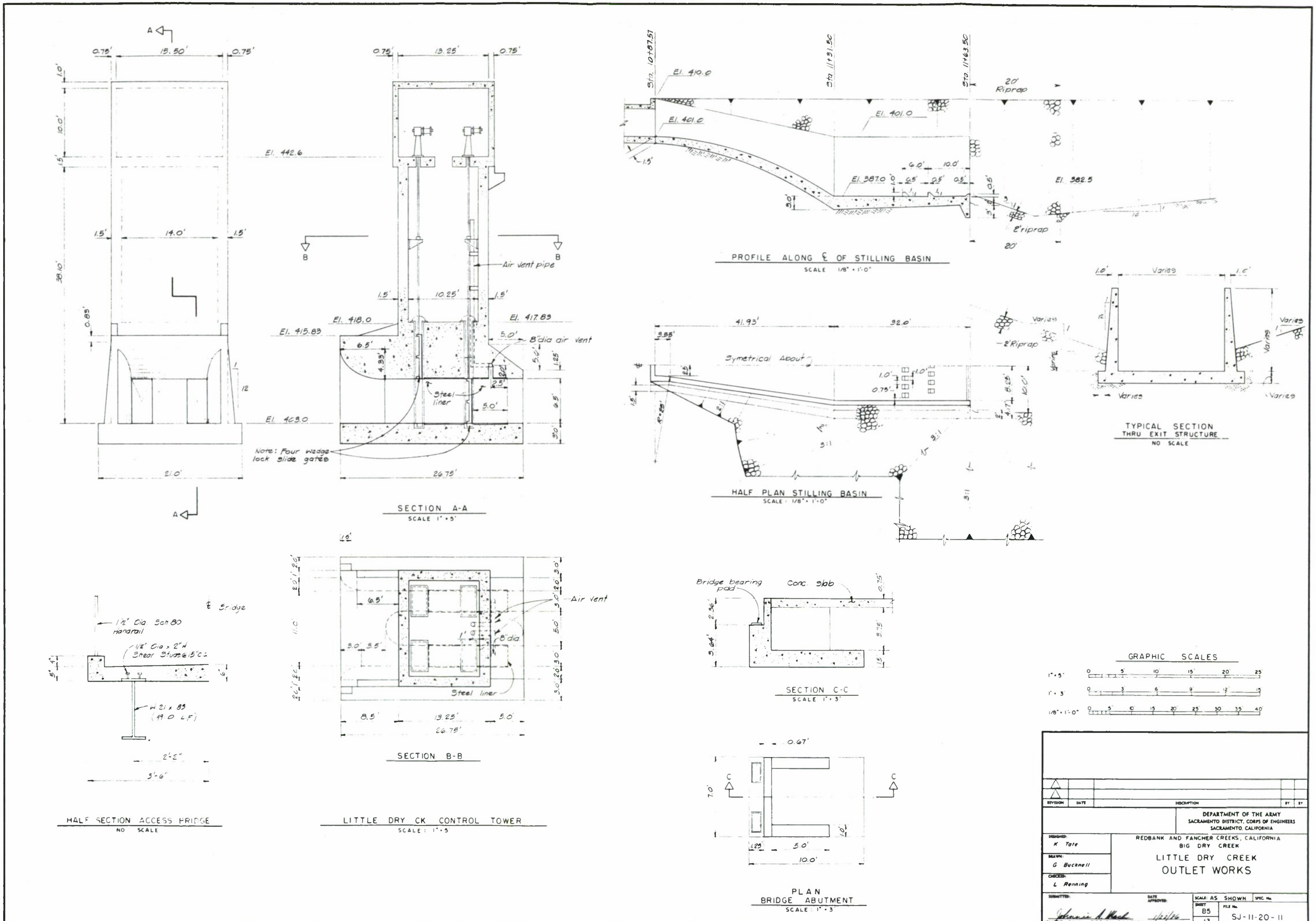
BIG DRY CREEK
OUTLET WORKS

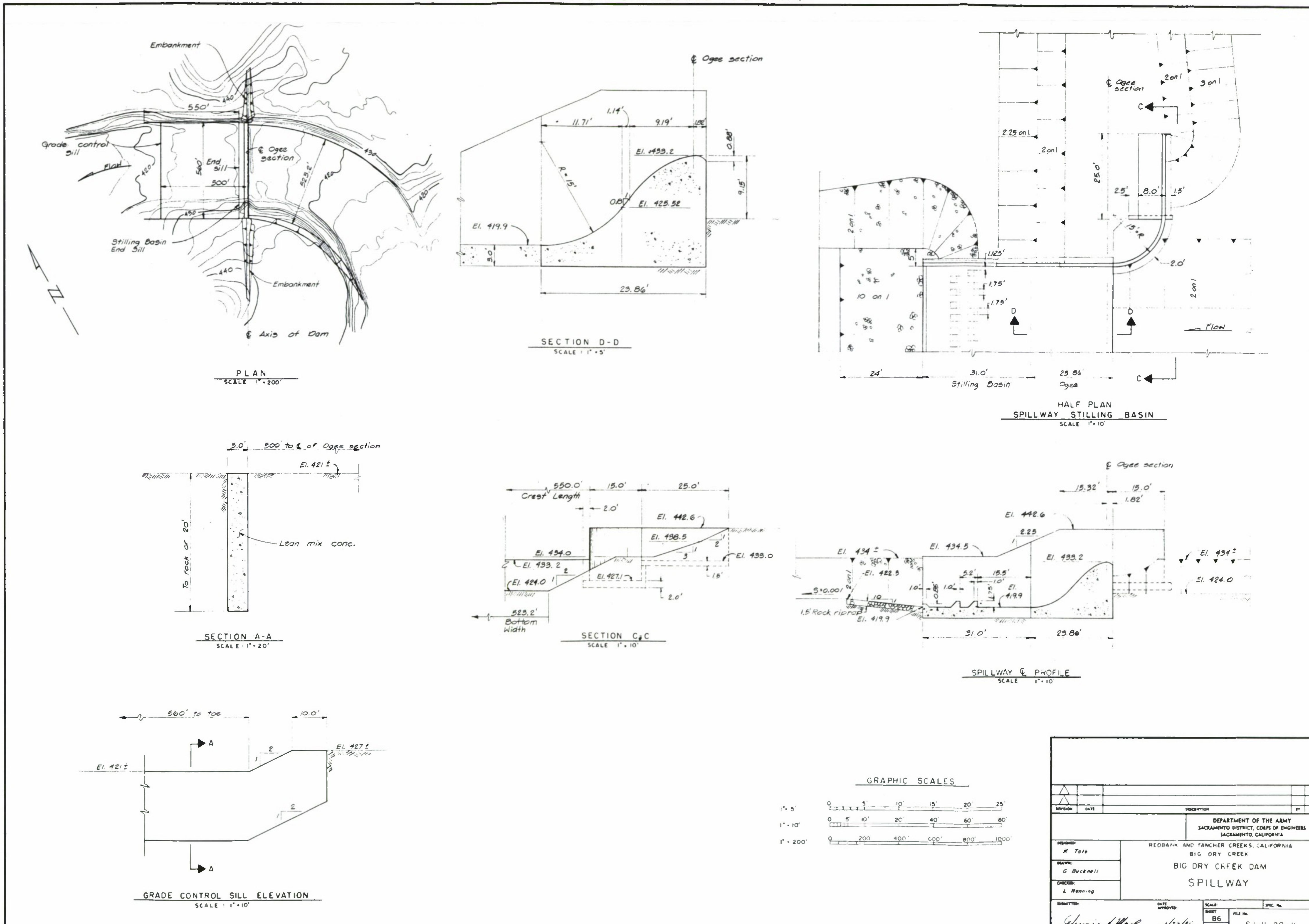
CHIEF, CIVIL DESIGN SECTION B

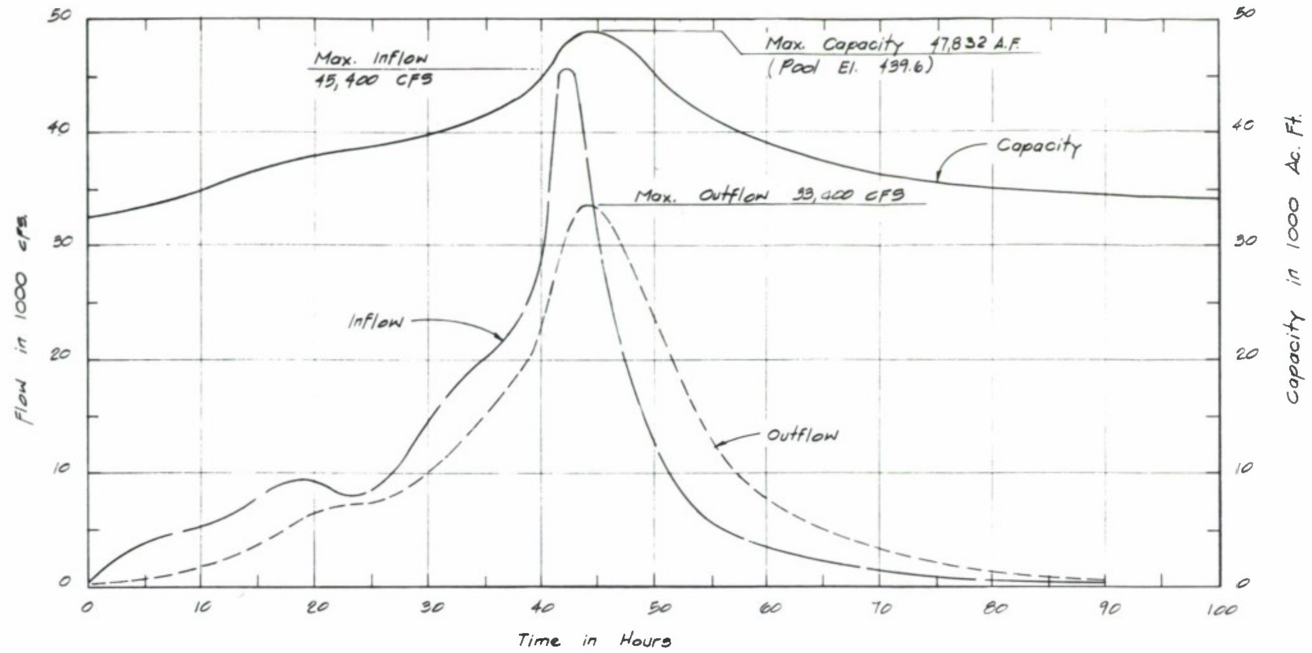
DATE APPROVED:

SCALE: AS SHOWN
SHEET B3 / 11
FILE No. SJ-11-20-11

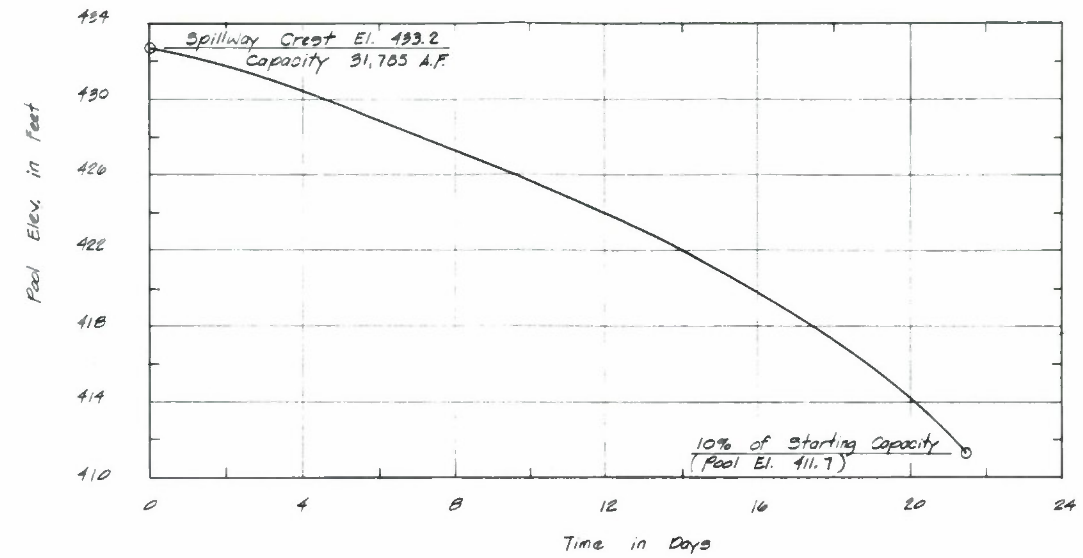

PROFILE ALONG ℄ OF OUTLET WORKS
SCALE: 1"=10'
APPROACH CHANNEL WALL ELEVATION
SCALE: 1"=5'
WINGWALL ELEVATION
SCALE: 1"=5'
SECTION B-B
SCALE: 1"=5'
TYPICAL CONDUIT SECTION
SCALE: 1"=3'
HALF PLAN APPROACH CHANNEL
SCALE: 1"=5'
TYPICAL SECTION
THRU APPROACH CHANNEL
SCALE: 1"=5'
SECTION A-A
TRANSITION
SCALE: 1"=5'
GRAPHIC SCALES
Riprap side and invert 20' passed stilling basin sill
Existing Ground El. 409 ±
Existing Embankment
Existing Ground El. 410
Approach Channel
Control Tower
Transition
Conduit
Stilling Basin
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
REDBANK AND FANCHER CREEKS, CALIFORNIA
BIG DRY CREEK
LITTLE DRY CREEK
OUTLET WORKS
DESIGNED: K. Tate
DRAWN: G. Bucknell
CHECKED: L. Renning
CHIEF, CIVIL DESIGN SECTION B
SCALE: AS SHOWN
SHEET B4 12
SJ-11-20-11


SECTION A-A
SCALE 1" = 5'
LITTLE DRY CK CONTROL TOWER
SCALE: 1" = 5'
SECTION B-B
HALF SECTION ACCESS BRIDGE
NO SCALE
PROFILE ALONG ℄ OF STILLING BASIN
SCALE 1/8" = 1'-0"
HALF PLAN STILLING BASIN
SCALE: 1/8" = 1'-0"
TYPICAL SECTION
THRU EXIT STRUCTURE
NO SCALE
SECTION C-C
SCALE 1" = 3'
PLAN
BRIDGE ABUTMENT
SCALE 1" = 3'
GRAPHIC SCALES
Note: Four wedge lock slide gates
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
REDBANK AND FANCHER CREEKS, CALIFORNIA
BIG DRY CREEK
LITTLE DRY CREEK
OUTLET WORKS
K Tate
G Bucknell
L Renning
CHIEF CIVIL DESIGN SECTION B
SCALE AS SHOWN
B5
13
SJ-11-20-11

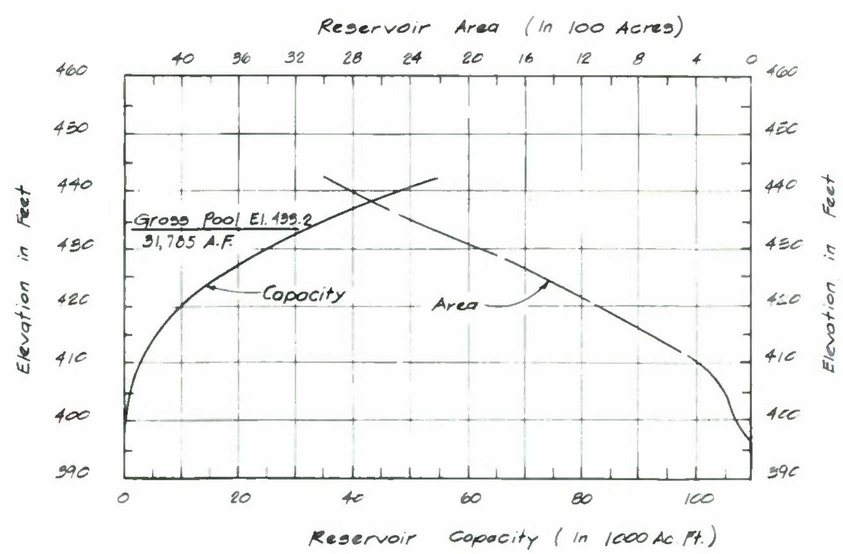

PLAN
SCALE 1" = 200'
SECTION D-D
SCALE 1" = 5'
HALF PLAN
SPILLWAY STILLING BASIN
SCALE 1" = 10'
SECTION A-A
SCALE 1" = 20'
SECTION C-C
SCALE 1" = 10'
SPILLWAY ℄ PROFILE
SCALE 1" = 10'
GRADE CONTROL SILL ELEVATION
SCALE 1" = 10'
GRAPHIC SCALES
Embankment
Grade control Sill
Flow
Stilling Basin End Sill
℄ Axis of Dam
℄ Ogee section
Lean mix conc.
To rock or 20'
Crest Length
Bottom Width
1.5' Rock riprap
Stilling Basin
Ogee
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
REDBANK AND FANCHER CREEKS, CALIFORNIA
BIG DRY CREEK
BIG DRY CREEK DAM
SPILLWAY
K. Tate
G. Bucknell
L. Renning
CHIEF, CIVIL DESIGN SECTION B
B6
14
SJ-11-20-11



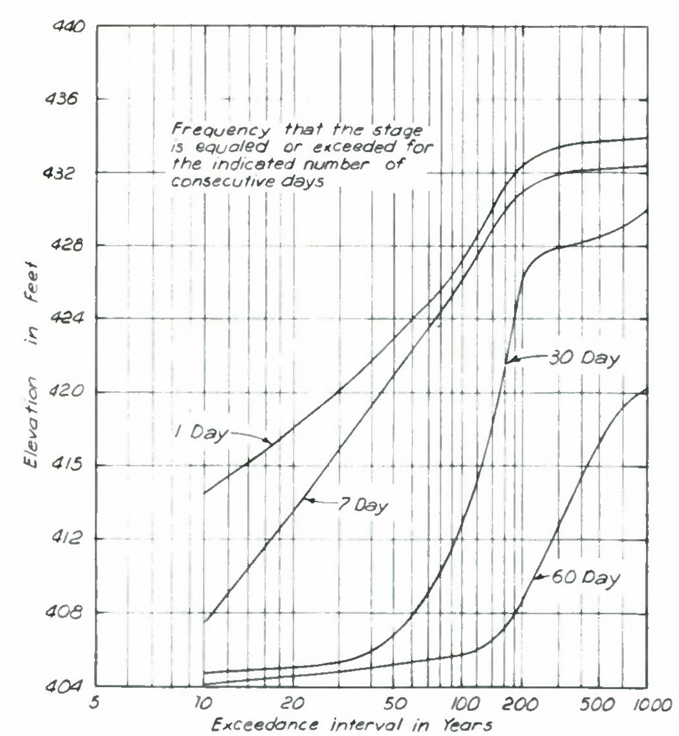
SPILLWAY DESIGN FLOOD (PMF) ROUTING CURVE



DRAWDOWN CURVE

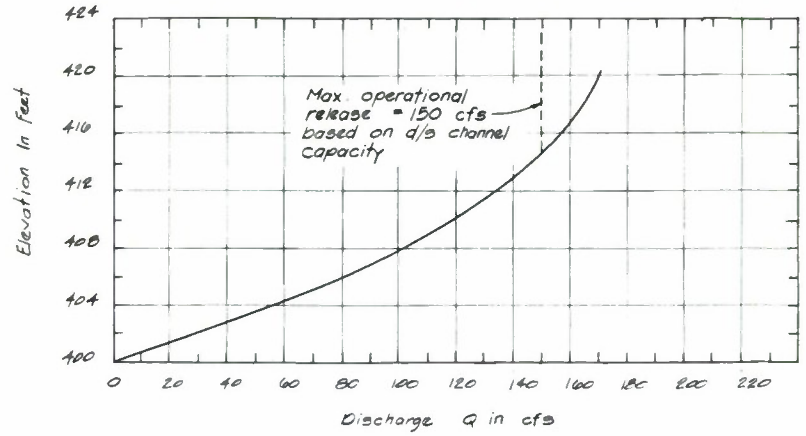


AREA – CAPACITY CURVE

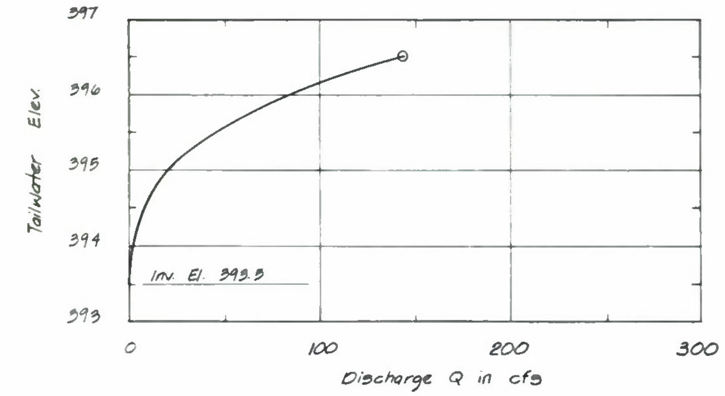


RESERVOIR STAGE FREQUENCY CURVE

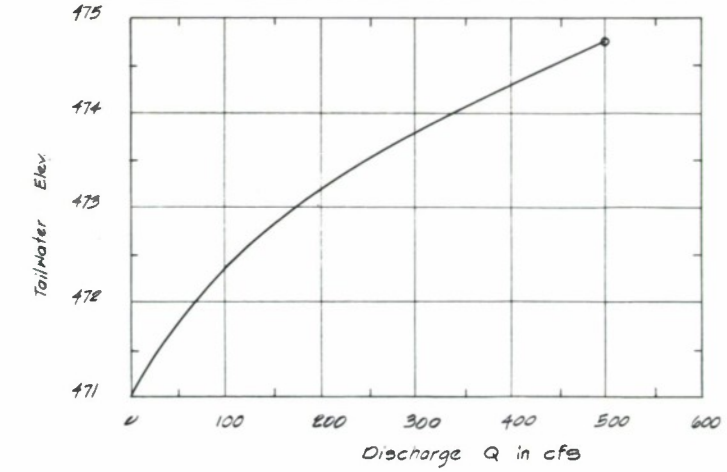
DEPARTMENT OF THE ARMY SACRAMENTO DISTRICT, CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA	
DESIGNED: W. O'Leary	REDBANK AND FANCHER CREEKS, CALIFORNIA BIG DRY CREEK BIG DRY CREEK DAM
DRAWN: G. Bucknell	
CHECKED: C. Nikolovic	HYDRAULIC DATA
SUBMITTED: Harold C. Shiff CHIEF, HYDRAULIC DESIGN SECTION	DATE APPROVED: 22 JAN 86 · SCALE: AS SHOWN · SHEET B7 / 15 · FILE No. SJ-11-20-11



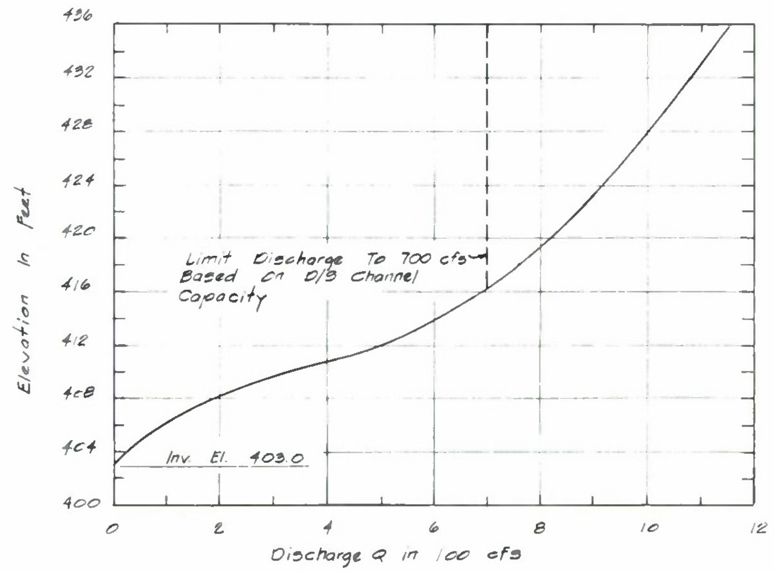
BIG DRY CREEK
OUTLET WORKS RATING CURVE



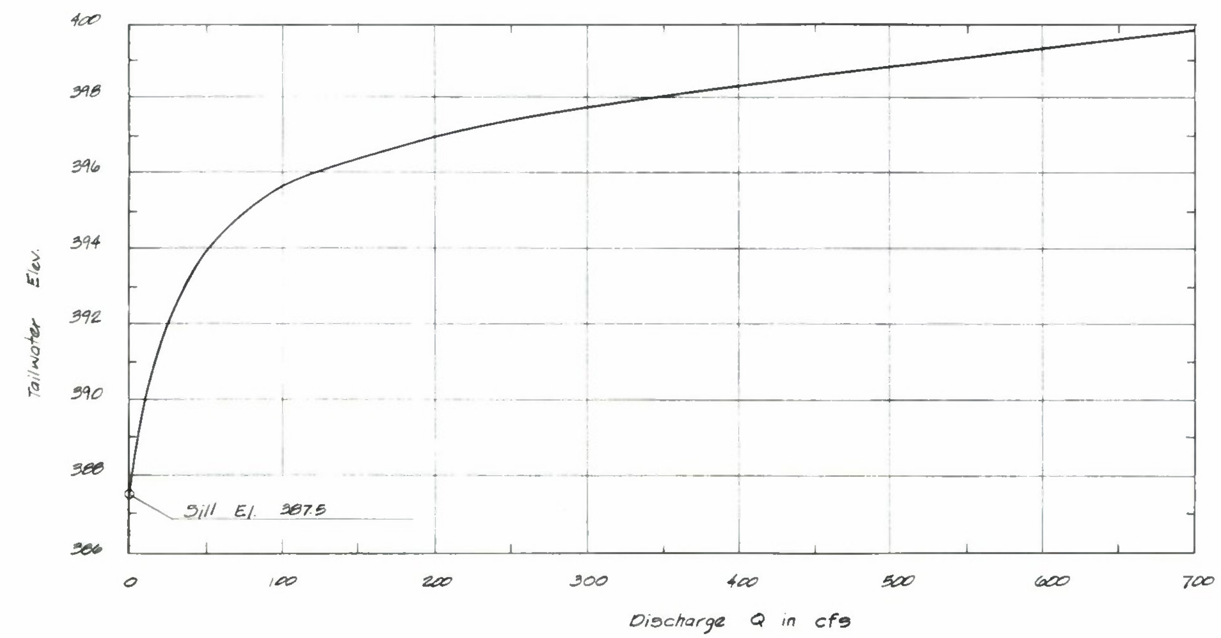
BIG DRY CREEK OUTLET WORKS
TAILWATER RATING CURVE



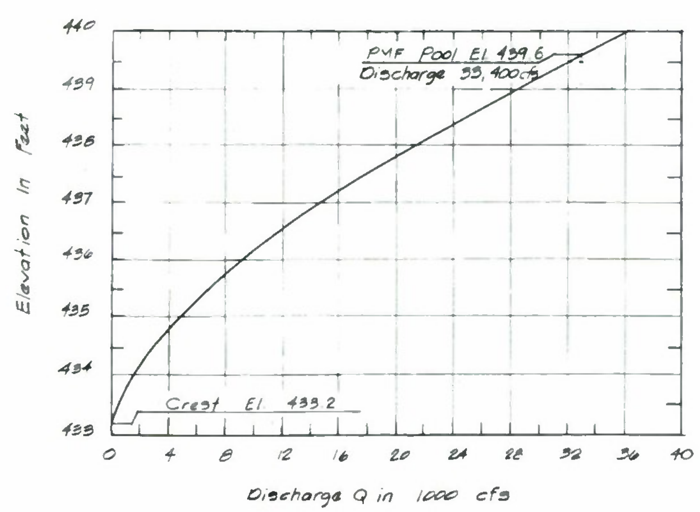
DOG CREEK OUTLET WORKS
TAILWATER RATING CURVE



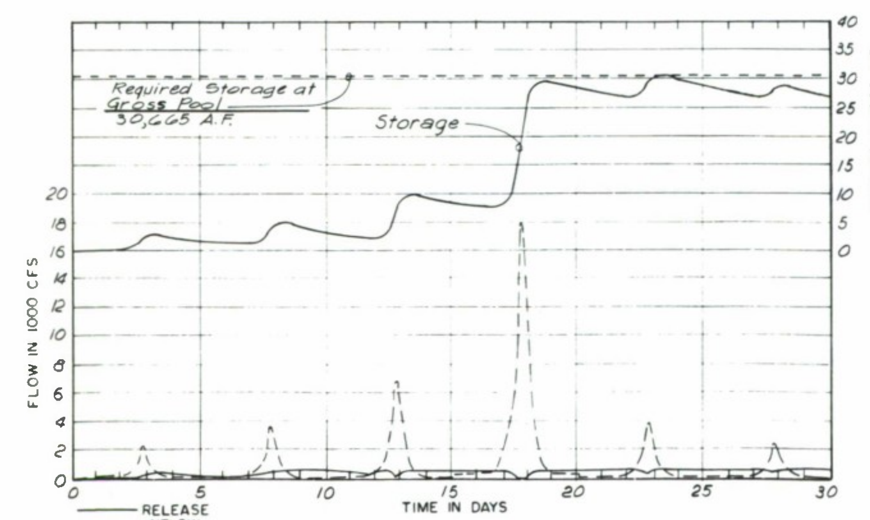
LITTLE DRY CREEK
OUTLET WORKS RATING CURVE



LITTLE DRY CREEK OUTLET WORKS
TAILWATER RATING CURVE



SPILLWAY DISCHARGE RATING CURVE



RESERVOIR DESIGN FLOOD (SPF) ROUTING CURVE

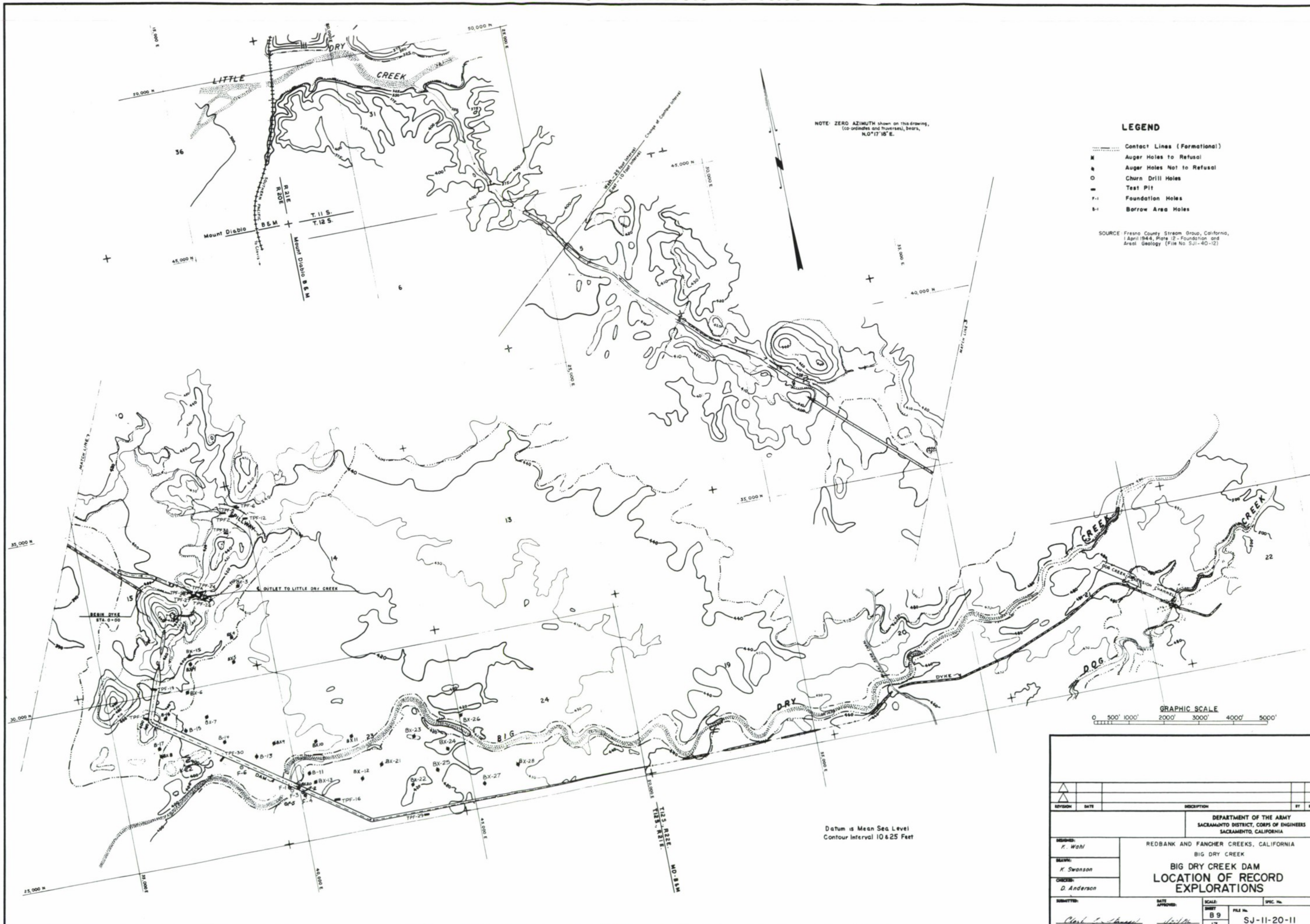
REVISION	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DESIGNED: W O'Leary
DRAWN: G Bucknell
CHECKED: C Mitkovic
SUBMITTED: Harold C. Huff, CHIEF HYDRAULIC DESIGN SECTION

REDBANK AND FANCHER CREEKS, CALIFORNIA
BIG DRY CREEK
BIG DRY CREEK DAM
HYDRAULIC DATA

DATE APPROVED: 22 JAN 86
SCALE: AS SHOWN
SHEET: 88 / 16
FILE No. SJ-11-20-11


LEGEND
Contact Lines (Formational)
Auger Holes to Refusal
Auger Holes Not to Refusal
Churn Drill Holes
Test Pit
Foundation Holes
Borrow Area Holes
SOURCE: Fresno County Stream Group, California, 1 April 1944, Plate 12 - Foundation and Areal Geology (File No. SJI-40-12)
NOTE: ZERO AZIMUTH shown on this drawing, (co-ordinates and traverses), bears, N.0°17'18"E.
Datum is Mean Sea Level
Contour Interval 10 & 25 Feet
GRAPHIC SCALE
0 500' 1000' 2000' 3000' 4000' 5000'
LITTLE DRY CREEK
BIG DRY CREEK
DOG CREEK
Mount Diablo B & M
T. 11 S.
T. 12 S.
R 21 E
R 20 E
T 12 S, R 22 E.
T 12 S, R 21 E.
MD-B&M
OUTLET TO LITTLE DRY CREEK
DOG CREEK DIVERSION CHANNEL
BEGIN DYKE STA. 0+00
DYKE
DAM
MATCH LINE
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
REDBANK AND FANCHER CREEKS, CALIFORNIA
BIG DRY CREEK
BIG DRY CREEK DAM
LOCATION OF RECORD EXPLORATIONS
DESIGNED: K. Wahl
DRAWN: K. Swanson
CHECKED: D. Anderson
SUBMITTED:
CHIEF, SOILS DESIGN SECTION
SHEET B9 17
FILE No. SJ-11-20-11

F - 1

DEPTH	Symbol	GR	SA	FI	MC	G_s	Description
0	SW-SM	1	94	5	-	2.79	SILTY SAND, grey, fine to medium grained sand, micaceous
5.0'	SP	18	80	2	-	-	GRAVELLY SAND, grey, fine to coarse grained sand, fine gravel
							At 10.0' depth, gravel becomes coarser
11.8'	SC	18	59	23	-	-	GRAVELLY CLAYEY SAND, grey, graded sand, fine gravel, micaceous
15.0'	SW-SM	2	88	10	-	2.86	SILTY SAND, brown, well graded sand, a few fine gravels
							At 20.0' depth, as above except increasing amounts of gravel
25.0'	SC	0	70	30			CLAYEY SAND, brown, graded sand

F - 1 - Cont'd

DEPTH	Symbol	GR	SA	FI	MC	G_s	Description
35.0'	CL	1	44	55	-	-	SANDY CLAY, brown, graded sand, fine gravel
40.0'	SC	1	52	47	-	-	CLAYEY SAND
43.0'	SC	19	59	22	-	-	GRAVELLY CLAYEY SAND, graded sand, fine gravel
45.0'	SP	3	93	4	-	2.78	SAND, brown, fine to coarse grained sand, small amounts of fine gravel
50.0'	SC-SW	2	89	9	10	-	CLAYEY SAND, well graded sand, γ_d = 122.6PCF
52.5'							

Vertical Scale: 1" = 2'

F - 2

DEPTH	Symbol	GR	SA	FI	Description
0	(SC)	-	-	-	CLAYEY SAND, loose
1.3'	(CL)	-	-	-	SANDY CLAY, small amount of fine gravel, loose
2.0'	SC	0	78	22	CLAYEY SAND, grey to brown, graded sand, hard to tight, some mica
7.5'	(SC)	-	-	-	CLAYEY SAND, brown, coarse grained sand, loose
15.4'		-	-	-	CLAYEY SAND, grey, fine grained sand, loose
16.0'	(CL)	-	-	-	SANDY CLAY, grey, fine grained sand, small amounts of gravel
20.4'	(SC)	-	-	-	CLAYEY SAND, grey, coarse grained sand, small amounts of fine gravel
21.8'					

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			GROUP SYMBOLS	TYPICAL NAMES
COARSE GRAINED SOILS 50% or more retained on the No. 200 sieve.	GRAVELS More than half of coarse fraction retained on the No. 4 sieve.	Clean gravels	GW	Well-graded gravels, gravel-sand mixtures, little or no fines.
			GP	Poorly-graded gravels, gravel-sand mixtures, little or no fines.
		Gravels with fines	GM	Silty gravels, gravel-sand mixtures.
			GC	Clayey gravels, gravel-sand-clay mixtures.
	SANDS More than half of coarse fraction passing the No. 4 sieve.	Clean sands	SW	Well-graded sands, gravelly sands, little or no fines.
			SP	Poorly-graded sands, gravelly sands, little or no fines.
		Sands with fines	SM	Silty sands, sand-silt mixtures.
			SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS More than 50% passing the No. 200 sieve.	SILTS AND CLAYS	Liquid Limit below 50%	ML	Inorganic silts and very fine sands, rock flour, silty fine sands or silts. Plasticity below "A" line.
			CL	Inorganic clays, gravelly clays, sandy clays, lean clays. Plasticity above "A" line.
			OL	Organic silts and organic clays. Plasticity below "A" line.
		Liquid Limit 50% and above	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts. Plasticity below "A" line.
			CH	Inorganic fat clays. Plasticity above "A" line.
			OH	Organic clays or organic silts. Plasticity below "A" line.
Highly organic soils			Pt	Peat, organic content greater than 50%.

LEGEND:

- GR — Gravel, percent by weight passing 3-inch sieve and retained on the No. 4 sieve.
- SA — Sands, percent by weight passing the No. 4 sieve and retained on the No. 200 sieve.
- FI — Fines, percent by weight passing the No. 200 sieve.
- G_s — Specific Gravity
- MC — Field Moisture Content in Percent of Dry Weight.
- ( ) — Visual Field Unified Soil Classification.
- (F) — Visual Field Classification - No Unified Soil Classification Available.

NOTES:

1. Classifications are in accordance with the Unified Soils Classification System (ASTM D-2487).
2. All sieve sizes on the chart are U.S. Standard.
3. The terms "silt" and "clay" are used respectively to distinguish materials exhibiting lower plasticity from those with higher plasticity. The minus No. 200 sieve material is silt if the liquid limit and plasticity index plot below the "A" line on the plasticity chart (ASTM D-2487) and is clay if the liquid limit and plasticity index plot above the "A" line on the chart.
4. Borderline Classification: Soils possessing characteristics of two groups are designated by combinations of group symbols. For example GW-GC, a well-graded gravel-sand mixture with a clay binder.
5. For additional Logs of Explorations in the Big Dry Creek area, see sheets B9-B29.
6. For Locations of Explorations see sheet B9.
7. Borings F-1 thru F-8 were drilled with a Churn Drill in July 1943.
8. Depth to groundwater is shown if measured.

GRAPHIC SCALES

1" = 2' — 0' 1' 2' 4' 6' 8' 10'

REVISION	DATE	DESCRIPTION	BY	BY
△				
△				

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DESIGNED: K. Swenson
DRAWN: K. Wahl
CHECKED: D. Anderson

REDBANK AND FANCHER CREEKS, CALIFORNIA
BIG DRY CREEK
BIG DRY CREEK DAM
RECORD LOGS OF EXPLORATIONS
FOUNDATION
CHURN DRILL HOLES - F-1 and F-2

SUBMITTED: [signature] CHIEF, SOILS DESIGN SECTION
DATE APPROVED: 4/22/86
SCALE:
SPEC. No.
SHEET B10 18
FILE No. SJ-11-20-11

ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING

F - 3

DEPTH		GR	SA	FI	
0 – 2.5'	(F)	-	-	-	not sampled
2.5' – 5.0'	SC	0	79	22	CLAYEY SAND, very fine to coarse grained sand At 4.0' depth, red, dense (hard pan)
5.0' – 7.5'	(SC)	-	-	-	CLAYEY SAND, small amount of clay, fine grained sand
7.5' – 10.0'		0	62	38	CLAYEY SAND, graded sand At 9.0' depth, CLAY layer, dark brown, hard
10.0' – 15.0'	(SP)	-	-	-	SAND, coarse grained sand
15.0' – 17.5'	(SC)	-	-	-	CLAYEY SAND, coarse grained sand, loose, quartz fragments
17.5' – 20.0'		-	-	-	CLAYEY SAND, clay balls, fine grained sand, small amounts of gravel, quartz fragments
20.0' – 22.5'	(SP)	-	-	-	SAND, coarse grained, small amount of fine gravel, loose
22.5' – 25.0'	(SC)	-	-	-	CLAYEY SAND, fine and coarse grained sand, small amount of fine gravel, loose
25.0' – 27.5'		-	-	-	CLAYEY SAND, fine grained sand, loose
27.5' – 30.0'		-	-	-	CLAYEY SAND
30.0' – 31.5'					CLAYEY SAND, tight
31.5' – 33.8'	(CL)	-	-	-	SANDY CLAY, yellow and brown, dry, sand composed of granite, very tight
33.8' – 35.0'	(SC)	-	-	-	CLAYEY SAND
35.0' – 39.0'	(CL)	-	-	-	SANDY CLAY, medium consistency

F - 4

DEPTH		GR	SA	FI	G_s	
0 – 1.5'	(SC)	-	-	-	-	CLAYEY SAND, grey
1.5' – 5.0'	(SP)	-	-	-	-	SAND, fine grained
5.0' – 10.0'	(SC)	-	-	-	-	CLAYEY SAND, fine grained
10.0' – 12.5'		-	-	-	-	CLAYEY SAND, brown, coarse grained sand
12.5' – 17.0'	SM	3	76	21	2.71	SILTY SAND, brown, graded sand, fine gravel, quartz fragments At 15.0' depth, loose
17.0' – 22.5'	SC	-	-	-	-	CLAYEY SAND, fine grained sand, mica flakes
22.5' – 30.0'		7	79	14	-	CLAYEY SAND, brown, graded sand, fine gravel, soft, quartz fragments
30.0' – 35.0'	SM-SP	3	91	6	2.69	SILTY SAND, fine to medium grained sand, fine gravel, quartz fragments

F - 5

DEPTH		
0 – 7.5'	(SC)	CLAYEY SAND
7.5' – 11.0'		CLAYEY SAND, small amounts of fine gravel
11.0' – 20.0'	(CL)	SANDY CLAY, brown, fine grained sand
20.0' – 22.5'		SANDY CLAY, brown, fine grained sand, tight
22.5' – 25.0'		CLAY, brown, tight, hard pan layers
25.0' – 27.5'		SANDY CLAY, brown, fine grained sand, tight
27.5' – 30.0'	(SC)	CLAYEY SAND, brown, est. 50% sand, est. 50% fines

F - 6

DEPTH		GR	SA	FI	G_s	
0 – 0.7'	(CL)	-	-	-	-	CLAY
0.7' – 12.5' (▽ 6.0')	SC	10	40	50	-	At 0.7' to 1.0' depth, dark grey CLAYEY SAND, light grey, hard
12.5' – 15.0'	(CL)	-	-	-	-	SANDY CLAY, light yellow, fine grained sand
15.0' – 25.0'	SC-SW	19	72	9	2.91	CLAYEY GRAVELLY SAND, light yellow, graded sand, fine grained gravel, granite fragments
25.0' – 30.0'	(SC)	-	-	-	-	CLAYEY SAND, graded sand, small amounts of fine gravel

Water level August 1945

NOTES:

For additional notes and legend see sheet B10.

Vertical Scale: 1" = 2'

GRAPHIC SCALE

1" = 2' — 0' 1' 2' 4' 6' 8' 10'

REVISION	DATE	DESCRIPTION	BY	BY

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

REDBANK AND FANCHER CREEKS, CALIFORNIA
BIG DRY CREEK
BIG DRY CREEK DAM
RECORD LOGS OF EXPLORATIONS
FOUNDATION
CHURN DRILL HOLES - F-3 thru F-6

DESIGNED: K. Swanson
DRAWN: K. Wohl
CHECKED: D. Anderson
SUBMITTED: [signature]
CHIEF, SOILS DESIGN SECTION
DATE APPROVED: [signature]
SCALE:
SPEC. No.
SHEET B11 19
FILE No. SJ-11-20-11

TPF A

DEPTH		
0	(CL)	SANDY CLAY, brown
2.0'	(F)	QUARTZ SCHIST, highly weathered
∇ 11.5'		Irregularly weathered
14.0'		Water level July 1963

TPF 2

DEPTH		
0	(CL)	SANDY CLAY, black, quartz fragments, (Topsoil)
3.0'	(F)	QUARTZ MICA SCHIST, weathered
∇ 11.0'		
14.0'		Water level July 1963

TPF 3A

DEPTH		
0	(CL)	SANDY CLAY, red, (Topsoil)
1.0'	(F)	MICA SCHIST, red iron oxide staining, weathered, quartz veins
12.0'		

TPF 5

DEPTH		
0	(CL)	SANDY CLAY, black, quartz fragments
2.5'	(F)	MICA SCHIST, soft, blocky
5.0'		

TPF 6

DEPTH		
0	(CL)	SANDY CLAY, red, some quartz gravels
2.5'	(F)	MICA SCHIST, quartz veins
4.0'		

TPF 7

DEPTH		GR	SA	FI	G_s	
0	CL	1	28	71	2.54	SANDY CLAY, brown, very fine to fine grained sand, quartz fragments, (Topsoil)
2.0'	(F)	-	-	-	-	MICA SCHIST, iron oxide stained, weathered
4.0'						

TPF 12

DEPTH		GR	SA	FI	G_s	
0	CL	0	27	73	2.67	SANDY CLAY, black, very fine to fine grained sand (Topsoil)
∇ 3.5'						
4.6'						Water level July 1963 At 4.6' depth, MICA SCHIST

TPF 16

DEPTH		GR	SA	FI	G_s	
0	(SC)	-	-	-	-	CLAYEY SAND, brown
4.6'	SC-SM	0	73	27	2.60	CLAYEY SAND, reddish-brown, very fine to medium grained sand
5.4'						

TPF 19

DEPTH		
0	(SC)	CLAYEY SAND, black
		At 4.8' depth, hard pan
∇ 5.0'		
5.8'		CLAYEY SAND, fine grained sand
9.6'		At 9.6' depth, SCHIST Water level August 1963

TPF 24

DEPTH		
0	(SC)	CLAYEY SAND, red
2.5'	(F)	SCHIST, decomposed
3.0'		

TPF 26

DEPTH		
0	(SC)	CLAYEY SAND, red, hard
2.0'		At 2.0' depth, SCHIST, decomposed

TPF 27

DEPTH		
0	(SC)	CLAYEY SAND
2.0'		At 2.0' depth, SCHIST

TPF 28

DEPTH		
0	(SC)	CLAYEY SAND, brown
2.0'		At 2.0' depth, SCHIST

TPF 29

DEPTH		GR	SA	FI	G_s	
0	SC	0	55	45	2.71	CLAYEY SAND, very fine to medium grained sand, cemented (Hard pan)
5.5'		-	-	-	-	SANDY CLAY, hard
6.5'	(CL)	-	-	-	-	CLAY, reddish, very little sand
7.2'	(F)	-	-	-	-	DECOMPOSED BEDROCK, red
8.0'	(CL)	-	-	-	-	SANDY CLAY, grey
10.0'						

TPF 30

DEPTH		GR	SA	FI	G_s	
0	(SC)	-	-	-	-	CLAYEY SAND, brown
1.5'	(CL)	-	-	-	-	SANDY CLAY, brown, hard
3.5'	SM	0	74	26	-	SILTY SAND, brown, very fine to medium grained sand, tight
5.0'	(CL)	0	36	64	2.64	SANDY CLAY, brown, graded sand
∇ 7.0'						
7.5'						Water level August 1963

VERTICAL SCALE: 1" = 2'

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			GROUP SYMBOLS	TYPICAL NAMES
COARSE GRAINED SOILS 50% or more retained on the No. 200 sieve.	GRAVELS More than half of coarse fraction retained on the No. 4 sieve.	Clean gravels	GW	Well-graded gravels, gravel-sand mixtures, little or no fines.
			GP	Poorly-graded gravels, gravel-sand mixtures, little or no fines.
		Gravels with fines	GM	Silty gravels, gravel-sand mixtures.
			GC	Clayey gravels, gravel-sand-clay mixtures.
	SANDS More than half of coarse fraction passing the No. 4 sieve.	Clean sands	SW	Well-graded sands, gravelly sands, little or no fines.
			SP	Poorly-graded sands, gravelly sands, little or no fines.
		Sands with fines	SM	Silty sands, sand-silt mixtures.
			SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS More than 50% passing the No. 200 sieve.	SILTS AND CLAYS	Liquid Limit below 50%	ML	Inorganic silts and very fine sands, rock flour, silty fine sands or silts. Plasticity below "A" line.
			CL	Inorganic clays, gravelly clays, sandy clays, lean clays. Plasticity above "A" line.
			OL	Organic silts and organic clays. Plasticity below "A" line.
		Liquid Limit 50% and above	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts. Plasticity below "A" line.
			CH	Inorganic fat clays. Plasticity above "A" line.
			OH	Organic clays or organic silts. Plasticity below "A" line.
Highly organic soils			Pt	Peat, organic content greater than 60%.

LEGEND:

- GR — Gravel, percent by weight passing 3-inch sieve and retained on the No. 4 sieve.
- SA — Sands, percent by weight passing the No. 4 sieve and retained on the No. 200 sieve.
- FI — Fines, percent by weight passing the No. 200 sieve.
- G_s — Specific Gravity.
- ∇ — Groundwater level.
- ( ) — Visual Field Unified Soil Classification.
- (F) — Visual Field Classification - No Unified Soil Classification Available.

NOTES:

1. Classifications are in accordance with the Unified Soils Classification System (ASTM D-2487).
2. All sieve sizes on the chart are U.S. Standard.
3. The terms "silt" and "clay" are used respectively to distinguish materials exhibiting lower plasticity from those with higher plasticity. The minus No. 200 sieve material is silt if the liquid limit and plasticity index plot below the "A" line on the plasticity chart (ASTM D-2487) and is clay if the liquid limit and plasticity index plot above the "A" line on the chart.
4. Borderline Classification: Soils possessing characteristics of two groups are designated by combinations of group symbols. For example GW-GC, a well-graded gravel-sand mixture with a clay binder.
5. For additional Logs of Explorations in the Big Dry Creek Area, see sheets B9-B29.
6. For location of explorations see sheet B9.
7. All Foundation Test Pit Trenches (TPF) were dug in 1963.
8. Depth to groundwater is shown if measured.

GRAPHIC SCALE

1" = 2' 0' 1' 2' 4' 6' 8' 10'

REVISION	DATE	DESCRIPTION	BY	BY
△				
△				

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DESIGNED: K. Swanson
DRAWN: K. Wahl
CHECKED: D. Anderson

REDBANK AND FANCHER CREEKS, CALIFORNIA
BIG DRY CREEK
BIG DRY CREEK DAM
RECORD LOGS OF EXPLORATIONS
FOUNDATION
TEST PITS

SUBMITTED: CHIEF, SOILS DESIGN SECTION
DATE APPROVED: 4/2/86
SHEET: B12 / 20
FILE No. SJ-11-20-11

ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING

B X - 3

DEPTH		GR	SA	FI	G_s	
0 – 1.5'	(CL)	-	-	-	-	SANDY CLAY, black. At 1.2' depth, 2" layer of hard pan
1.5' – 4.7'	SC	0	51	46	2.58	CLAYEY SAND, brown, very fine to medium grained sand
4.7' – 8.5'	CL	0	36	61	2.51	SANDY CLAY, grey, very fine to fine grained sand

B X - 6

DEPTH		MC	
0 – 7.0'	(SC)	6	CLAYEY SAND. At 6.0' depth sands become coarser

▽ 7.0' Water level JULY 1943

B X - 9

DEPTH		GR	SA	FI	G_s	
0 – 7.0'	SC	0	68	42	2.72	CLAYEY SAND, brown, very fine to fine grained sand. At 2.0' depth, tight

B X - 12

DEPTH		GR	SA	FI	MC	G_s	
0 – 4.1'	SC-SM	0	75	25	3	2.84	CLAYEY SAND, brown, very fine to fine grained sand
4.1' – 8.0'	SC	0	67	33	-	-	CLAYEY SAND, brown, very fine to medium grained sand
8.0' – 12.0'	SC	0	74	28	-	-	CLAYEY SAND, brown, well graded sand

B X - 4

DEPTH		GR	SA	FI	
0 – 2.0'	(SC)	-	-	-	CLAYEY SAND, grey, fine grained sand
2.0' – 5.2'	SC	0	84	36	CLAYEY SAND, brown, very fine to fine grained sand
5.2' – 8.0'	(SP)	-	-	-	GRAVELLY SAND, medium to coarse grained sand

B X - 7

DEPTH		GR	SA	FI	MC	G_s	
0 – 8.0'	SC	0	86	32	4	2.61	CLAYEY SAND, brown, very fine to medium grained sand. Below 5' depth, tight

B X - 10

DEPTH		GR	SA	FI	MC	
0 – 1.5'	(CL)	-	-	-	-	SILTY CLAY, grey
1.5' – 3.5'	SC	0	51	49	-	CLAYEY SAND, black
3.5' – 4.4'	(SC)	-	-	-	16	CLAYEY SAND, grey
4.4' – 7.0'	(CL)	-	-	-	-	SANDY CLAY, brown

B X - 13

DEPTH		GR	SA	FI	G_s	
0 – 6.5'	SC	0	69	31	2.72	CLAYEY SAND, brown, very fine to fine grained sand. At 4.8' depth, hard pan

B X - 15

DEPTH		GR	SA	FI	G_s	
0 – 6.5'	SC-SM	0	73	27	2.72	SILTY SAND, light brown, very fine to fine grained sand
6.5' – 7.0'	(SP)	-	-	-	-	GRAVELLY SAND, medium to coarse grained sand, fine gravel

B X - 5

DEPTH		GR	SA	FI	MC	G_s	
0 – 3.5'	SC	0	56	42	-	2.65	CLAYEY SAND, brown, fine grained sand. At 3.4' depth, 2" hard pan layer
3.5' – 8.0'	CL	0	39	61	6	-	SANDY CLAY, brown, very fine to fine grained sand
8.0' – 11.0'	CL	0	40	60	-	2.61	SANDY CLAY, brown, very fine to medium grained sand

▽ 8.5' Water level JULY 1945

B X - 8

DEPTH		GR	SA	FI	
0 – 2.1'	SC	0	64	36	CLAYEY SAND, brown, very fine to medium grained sand. At 2.1' depth, hard pan layer
2.1' – 7.0'	(SC)				CLAYEY SAND, brown, medium grained sand
7.0' – 8.0'	(CL)	-	-	-	SANDY CLAY

▽ 7.0' Water level JULY 1945

B X - 11

DEPTH		GR	SA	FI	
0 – 2.6'	(SC)	-	-	-	CLAYEY SAND. At 2.5' depth, hard pan layer
2.6' – 6.0'	SC	0	56	42	CLAYEY SAND, very fine to coarse grained sand

B X - 14

DEPTH		GR	SA	FI	G_s	
0 – 7.0'	SC	0	52	46	2.64	CLAYEY SAND, brown, very fine to medium grained sand
7.0' – 7.5'	(SP)	-	-	-	-	GRAVELLY SAND, medium to coarse grained sand, fine gravel

▽ 7.0' Water level JULY 1945

Vertical Scale: 1" = 2'

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			GROUP SYMBOLS	TYPICAL NAMES
COARSE GRAINED SOILS 50% or more retained on the No. 200 sieve.	GRAVELS More than half of coarse fraction retained on the No. 4 sieve.	Clean gravels	GW	Well-graded gravels, gravel-sand mixtures, little or no fines.
			GP	Poorly-graded gravels, gravel-sand mixtures, little or no fines.
		Gravels with fines	GM	Silty gravels, gravel-sand mixtures.
			GC	Clayey gravels, gravel-sand-clay mixtures.
	SANDS More than half of coarse fraction passing the No. 4 sieve.	Clean sands	SW	Well-graded sands, gravelly sands, little or no fines.
			SP	Poorly-graded sands, gravelly sands, little or no fines.
		Sands with fines	SM	Silty sands, sand-silt mixtures.
			SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS More than 50% passing the No. 200 sieve.	SILTS AND CLAYS	Liquid Limit below 50%	ML	Inorganic silts and very fine sands, rock flour, silty fine sands or silts. Plasticity below "A" line.
			CL	Inorganic clays, gravelly clays, sandy clays, lean clays. Plasticity above "A" line.
			OL	Organic silts and organic clays. Plasticity below "A" line.
		Liquid Limit 50% and above	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts. Plasticity below "A" line.
			CH	Inorganic fat clays. Plasticity above "A" line.
			OH	Organic clays or organic silts. Plasticity below "A" line.
Highly organic soils			Pt	Peat, organic content greater than 50%

LEGEND

- GR — Gravel, percent by weight passing 3-inch sieve and retained on the No. 4 sieve.
- SA — Sands, percent by weight passing the No. 4 sieve and retained on the No. 200 sieve.
- FI — Fines, percent by weight passing the No. 200 sieve.
- G_s — Specific Gravity.
- ▽ — Groundwater level.
- MC — Field Moisture Content in Percent of Dry Weight.
- MC — Moisture Content.
- ( ) — Visual Field Unified Soil Classification.

NOTES:

1. Classifications are in accordance with the Unified Soils Classification System (ASTM D-2487).
2. All sieve sizes on the chart are U.S. Standard.
3. The terms "silt" and "clay" are used respectively to distinguish materials exhibiting lower plasticity from those with higher plasticity. The minus No. 200 sieve material is silt if the liquid limit and plasticity index plot below the "A" line on the plasticity chart (ASTM D-2487) and is clay if the liquid limit and plasticity index plot above the "A" line on the chart.
4. Borderline Classification: Soils possessing characteristics of two groups are designated by combinations of group symbols. For example GW-GC, a well-graded gravel-sand mixture with a clay binder.
5. For additional Logs of Explorations in the Big Dry Creek Area, see sheets B9 - B29.
6. For location of explorations see sheet B9
7. All Borrow Explorations (BX) were dug with either 6" or 8" hand augers in 1945.
8. Depth to groundwater is shown if measured.

GRAPHIC SCALE

1" = 2' 0' 1' 2' 4' 6' 8' 10'

REVISION	DATE	DESCRIPTION	BY
△			
△			

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DESIGNED: K. Swanson
DRAWN: K. Wahl
CHECKED: D. Anderson

REDBANK AND FANCHER CREEKS, CALIFORNIA
BIG DRY CREEK
BIG DRY CREEK DAM
RECORD LOGS OF EXPLORATIONS
BORROW AREA

SUBMITTED: CHIEF, SOILS DESIGN SECTION
DATE APPROVED:
SCALE:
SPEC No.
SHEET B13 / 21
FILE No. SJ-11-20-11

B - 11

DEPTH		GR	SA	FI	G_s	Description
0 – 8.0'	SM	0	73	27	2.75	SILTY SAND, light brown, dry, a trace of clay
8.0' – 10.0'	SC	0	53	47	2.68	CLAYEY SAND, slightly red, becomes more moist with depth
10.0' – ▽ 14.0'	SC	0	52	46	2.74	CLAYEY SAND, yellowish-brown, wet
14.0' – 15.0'	(SP)	-	-	-	-	SAND

Water Level December 1938

B - 13

DEPTH		GR	SA	FI	G_s	Description
0 – 6.0'	SC	0	56	42	2.74	CLAYEY SAND, reddish-brown, moist, increased clay content with depth
6.0' – 10.0'	SC	0	83	37	2.69	CLAYEY SAND, brown
10.0' – ▽ 15.0'	SC	0	56	44	2.69	CLAYEY SAND, reddish-brown, wet, very little gravel
15.0' – 16.0'	CL	0	34	66	2.72	SANDY CLAY, brown, very little sand, sticky

Water Level December 1936

B - 14

DEPTH		GR	SA	FI	G_s	Description
0 – 5.0'	SC	0	59	41	2.72	CLAYEY SAND, light brown, dry, hard
5.0' – ▽ 9.0'	CL	0	29	71	2.73	SANDY CLAY, reddish-brown, moist
9.0' – 11.0'	CL	0	41	59	2.72	SANDY CLAY, red, hard

Water Level December 1938

B - 15

DEPTH		GR	SA	FI	G_s	Description
0 – 8.0'	SC	0	62	36	2.69	CLAYEY SAND, light brown, dry. At 4.0' depth, becomes moist and gravelly
8.0' – 15.0'	SC	0	66	34	2.68	CLAYEY SAND, red, moist
15.0' – 16.0'	SC	0	70	30	2.70	CLAYEY SAND, brown, wet, becoming sandier with depth

B - 16

DEPTH		GR	SA	FI	G_s	Description
0 – 3.0'	CL	0	36	64	2.68	SANDY CLAY, black, moist, (adobe)
3.0' – ▽ 11.0' – 12.0'	SC	0	70	30	2.70	CLAYEY SAND, reddish-yellow, wet
12.0' – 15.0'	SC	0	60	40	2.72	CLAYEY SAND, brown, very hard

Water Level December 1938

B - 17

DEPTH		GR	SA	FI	G_s	Description
0 – 2.0'	SC	0	54	46	2.69	CLAYEY SAND, dry, light brown,
2.0' – ▽ 10.0'	CL	-	-	-	2.73	SANDY CLAY, brown, moist, becomes wet and gravelly with depth
10.0' – 13.0'	SC	-	59	41	2.70	CLAYEY SAND, red, sticky

Water Level December 1956

Vertical Scale: 1" = 2'

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			GROUP SYMBOLS	TYPICAL NAMES
COARSE GRAINED SOILS 50% or more retained on the No. 200 sieve.	GRAVELS More than half of coarse fraction retained on the No. 4 sieve.	Clean gravels	GW	Well-graded gravels, gravel-sand mixtures, little or no fines.
			GP	Poorly-graded gravels, gravel-sand mixtures, little or no fines.
		Gravels with fines	GM	Silty gravels, gravel-sand mixtures.
			GC	Clayey gravels, gravel-sand-clay mixtures.
	SANDS More than half of coarse fraction passing the No. 4 sieve.	Clean sands	SW	Well-graded sands, gravelly sands, little or no fines.
			SP	Poorly-graded sands, gravelly sands, little or no fines.
		Sands with fines	SM	Silty sands, sand-silt mixtures.
			SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS More than 50% passing the No. 200 sieve.	SILTS AND CLAYS	Liquid Limit below 50%	ML	Inorganic silts and very fine sands, rock flour, silty fine sands or silts. Plasticity below "A" line.
			CL	Inorganic clays, gravelly clays, sandy clays, lean clays. Plasticity above "A" line.
			OL	Organic silts and organic clays. Plasticity below "A" line.
		Liquid Limit 50% and above	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts. Plasticity below "A" line.
			CH	Inorganic fat clays. Plasticity above "A" line.
			OH	Organic clays or organic silts. Plasticity below "A" line.
Highly organic soils			Pt	Peat, organic content greater than 60%.

LEGEND:

- GR — Gravel, percent by weight passing 3-inch sieve and retained on the No. 4 sieve.
- SA — Sands, percent by weight passing the No. 4 sieve and retained on the No. 200 sieve.
- FI — Fines, percent by weight passing the No. 200 sieve.
- G_s — Specific Gravity.
- ▽ — Groundwater level.
- ( ) — Visual Field Unified Soil Classification.

NOTES:

1. Classifications are in accordance with the Unified Soils Classification System (ASTM D-2487).
2. All sieve sizes on the chart are U.S. Standard.
3. The terms "silt" and "clay" are used respectively to distinguish materials exhibiting lower plasticity from those with higher plasticity. The minus No. 200 sieve material is silt if the liquid limit and plasticity index plot below the "A" line on the plasticity chart (ASTM D-2487) and is clay if the liquid limit and plasticity index plot above the "A" line on the chart.
4. Borderline Classification: Soils possessing characteristics of two groups are designated by combinations of group symbols. For example GW-GC, a well-graded gravel-sand mixture with a clay binder.
5. For additional logs of Explorations in the Big Dry Creek Area see sheets B9-B29.
6. For location of explorations see sheet no. B9.
7. Explorations B-11, 13-17 were drilled in 1936.
6. Depth to water table is shown if measured.

GRAPHIC SCALE

1" = 2' 0 1' 2' 4' 6' 8' 10'

REVISION	DATE	DESCRIPTION	BY
△			
△			

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DESIGNED: K. Swanson
DRAWN: K Wahl
CHECKED: D Anderson
SUBMITTED: [signature] CHIEF, SOILS DESIGN SECTION
DATE APPROVED: [signature]

REDBANK AND FANCHER CREEKS, CALIFORNIA
BIG DRY CREEK
BIG DRY CREEK DAM
RECORD LOGS OF EXPLORATIONS
BORROW AREA

SCALE: | SPEC. No.
SHEET B14 22 | FILE No. SJ-11-20-11

B X - 2 0

DEPTH	Class	GR	SA	FI	G_s	Description
0 – 1.0'	SC	0	86	14	-	CLAYEY SAND, dark grey, very fine to fine grained sand
1.0' – 10.0'	SM	0	82	18	2.70	SILTY SAND, brown, very fine to fine grained sand, loose
10.0' – 11.0'	(CL)	-	-	-	-	SANDY CLAY, brown, tight, a few quartz gravels
11.0' – 14.0'	(CL)	-	-	-	-	SANDY CLAY, brown, some gravel, loose
14.0' – 17.0'	SM	3	61	16	2.64	SILTY SAND, brown, medium to coarse grained sand, fine quartz gravel
17.0' – 19.0'	SC-SW	3	88	9		CLAYEY SAND, brown, well graded sand, fine gravel to 3/8" maximum

B X - 2 1

DEPTH	Class	GR	SA	FI	Description
0 – 4.0'	(CL)	-	-	-	SANDY CLAY, brown, fine grained sand, tight
4.0' – 6.5'	SC	0	87	13	CLAYEY SAND, very fine to medium grained sand, tight
6.5' – 9.5'	(CL)	-	-	-	SANDY CLAY, coarse grained sand, a few gravels
9.5' – 10.0'	SC	0	77	23	CLAYEY SAND, well graded sand

B X - 2 2

DEPTH	Class	GR	SA	FI	Description
0 – 9.5'	SC	0	67	33	CLAYEY SAND, brown, very fine to fine grained sand, loose At 4.0' depth, sand becomes coarser
9.5' – 10.0'		0	76	24	CLAYEY SAND, very fine to medium grained sand

B X - 2 3

DEPTH	Class	Description
0 – 1.8'	(SC)	CLAYEY SAND, black
1.8' – 3.6'	(SC)	CLAYEY SAND, black, loose
3.6' – 5.0'	(CL)	SANDY CLAY, brown, loose
5.0' – 10.0'	(SC)	CLAYEY SAND, brown, coarse grained sand, a few fine gravels

6.0' ▽ Water level 5 Aug 1943

B X - 2 4

DEPTH	Class	Description
0 – 2.6'	(SC)	CLAYEY SAND, black
2.6' – 3.6'	(CL)	SANDY CLAY, brown, fine grained sand, hard
3.6' – 4.2'	(CL)	SANDY CLAY, brown, hard
4.2' – 7.5'	(CL)	SANDY CLAY, brown, tight
7.5' – 10.0'	(CL)	SANDY CLAY, greyish-brown, loose, micaceous

8.0' ▽ Water level 5 Aug 1943

B X - 2 5

DEPTH	Class	GR	SA	FI	G_s	Description
0 – 2.0'	(SC)	-	-	-	-	CLAYEY SAND, brown
2.0' – 7.2'	SC	0	54	46	2.63	CLAYEY SAND, brown, very fine to medium grained sand, hard, G_s = 2.63 At 5.0' depth, loose
7.2' – 8.5'	(CL)	-	-	-	-	SANDY CLAY, brown, hard, micaceous
8.5' – 10.0'	SC	1	60	39	-	CLAYEY SAND, brown, very fine to medium grained sand, fine gravel, loose

B X - 2 6

DEPTH	Class	GR	SA	FI	Description
0 – 1.0'	(SC)	-	-	-	CLAYEY SAND, black
1.0' – 4.0'	(CL)	-	-	-	SANDY CLAY, brown, hard
4.0' – 5.0'	(CL)	-	-	-	SANDY CLAY, brown, loose
5.0' – 6.0'	(CL)	-	-	-	SANDY CLAY, brown, a few gravels, hard
6.0' – 7.0'	(CL)	-	-	-	SANDY CLAY, brown, a few gravels
7.0' – 8.0'	(CL)	-	-	-	SANDY CLAY, brown, coarse grained sand, loose
8.0' – 10.0'	SC	-	61	39	CLAYEY SAND, brown, very fine to medium grained sand, loose, micaceous

B X - 2 7

DEPTH	Class	GR	SA	FI	Description
0 – 1.4'	(SC)	-	-	-	CLAYEY SAND
1.4' – 3.0'	(CL)	-	-	-	SANDY CLAY, brown, hard
3.0' – 4.0'	(CL)	-	-	-	SANDY CLAY, brown, loose, micaceous
4.0' – 6.5'	SC	0	61	39	CLAYEY SAND, dark brown, very fine to medium grained sand, loose, micaceous
6.5' – 7.0'	(CL)	-	-	-	SANDY CLAY, brown, loose, micaceous
7.0' – 8.0'	(CL)	-	-	-	SANDY CLAY, reddish-brown, loose
8.0' – 10.0'	(CL)	-	-	-	SANDY CLAY, brown, fine grained sand, loose, micaceous

B X - 2 8

DEPTH	Class	GR	SA	FI	Description
0 – 1.0'	(SC)	-	-	-	CLAYEY SAND, brownish-grey
1.0' – 10.0'	SC	1	72	27	CLAYEY SAND, brown, very fine to fine grained sand, generally loose with some hard layers

Vertical Scale: 1" = 2'

NOTE:
For additional notes and legend, see sheet B14.

GRAPHIC SCALE
1" = 2' 0' 1' 2' 4' 6' 8' 10'

REVISION	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

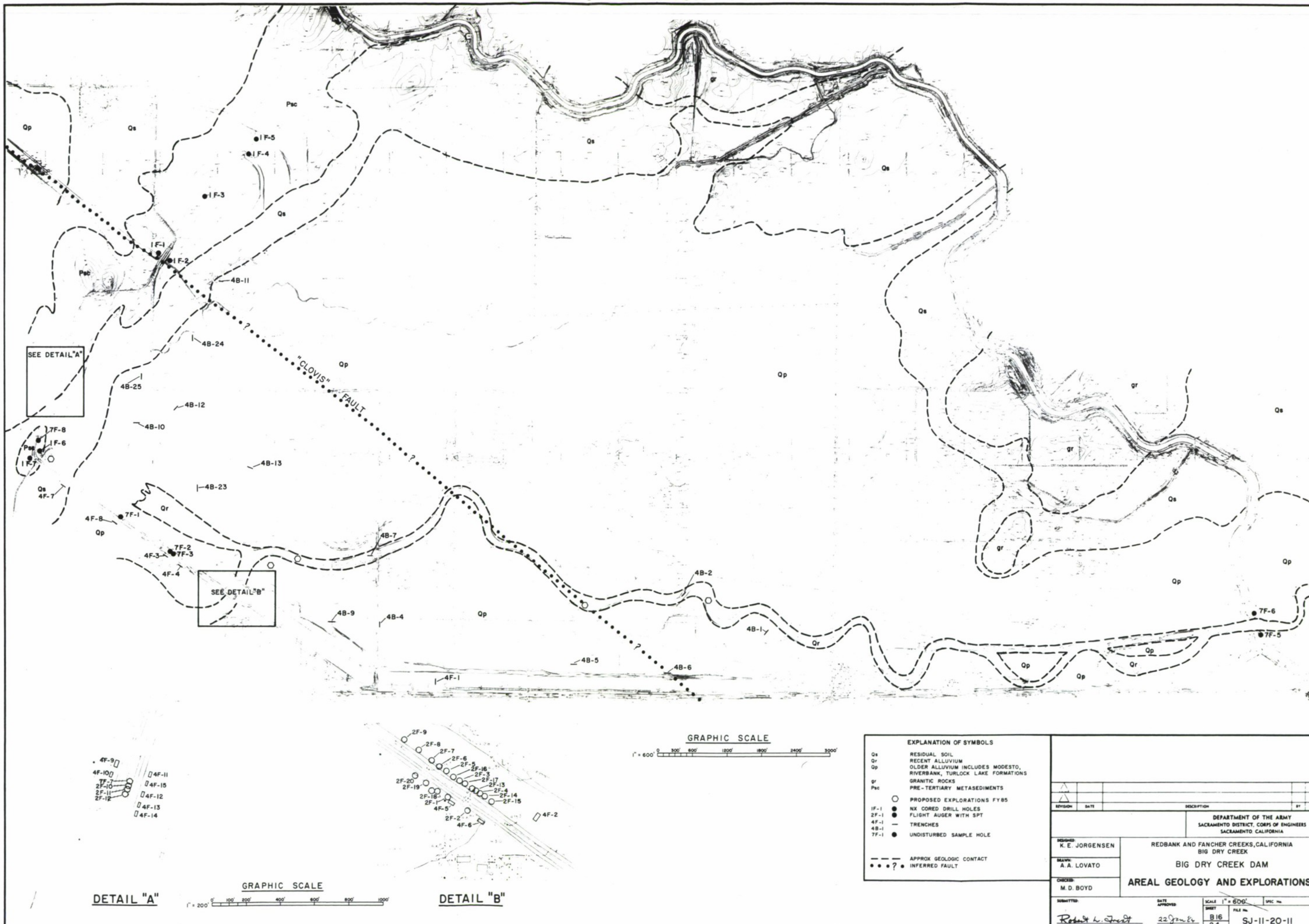
DESIGNED: K. Swenson
DRAWN: K. Wahl
CHECKED: D. Anderson
SUBMITTED: [signature]
CHIEF, SOILS DESIGN SECTION

REDBANK AND FANCHER CREEKS, CALIFORNIA
BIG DRY CREEK

BIG DRY CREEK DAM
RECORD LOGS OF EXPLORATIONS
BORROW AREA

DATE APPROVED: [signature]
SCALE:
SHEET B15 / 23
FILE No. SJ-11-20-11
SPEC. No.

FUNCTION ANALYSIS - VE PAYS



EXPLANATION OF SYMBOLS

Qs	RESIDUAL SOIL
Qr	RECENT ALLUVIUM
Qp	OLDER ALLUVIUM INCLUDES MODESTO, RIVERBANK, TURLOCK LAKE FORMATIONS
gr	GRANITIC ROCKS
Psc	PRE-TERTIARY METASEDIMENTS
○	PROPOSED EXPLORATIONS FY85
1F-1 ●	NX CORED DRILL HOLES
2F-1 ●	FLIGHT AUGER WITH SPT
4F-1 4B-1 —	TRENCHES
7F-1 ●	UNDISTURBED SAMPLE HOLE
— —	APPROX GEOLOGIC CONTACT
• • ? •	INFERRED FAULT

REVISION	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO CALIFORNIA

DESIGNED: K. E. JORGENSEN
DRAWN: A.A. LOVATO
CHECKED: M. D. BOYD
SUBMITTED: Robert L. Frost, CHIEF, GEOLOGY SECTION

REDBANK AND FANCHER CREEKS, CALIFORNIA
BIG DRY CREEK

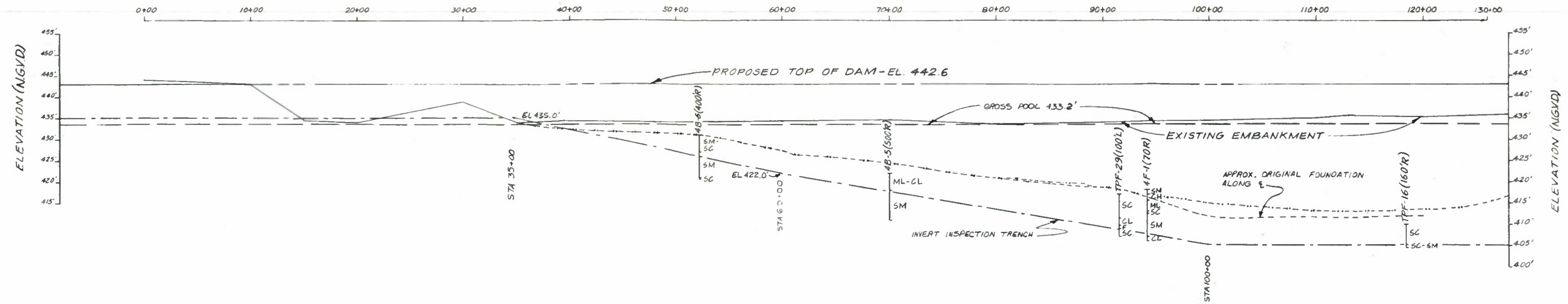
BIG DRY CREEK DAM

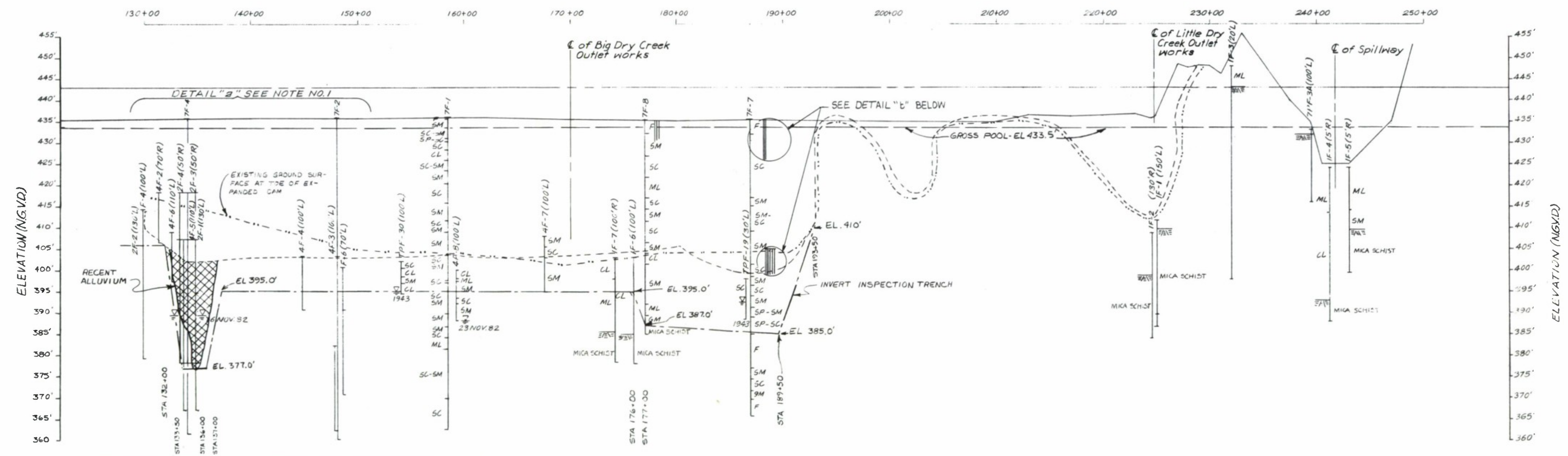
AREAL GEOLOGY AND EXPLORATIONS

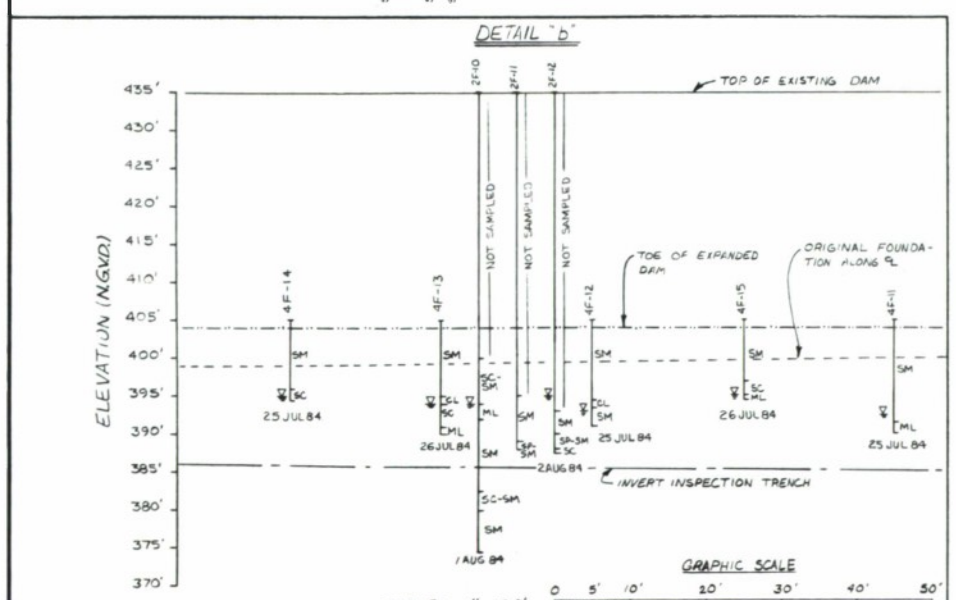
DATE APPROVED: 22 Jan 84
SCALE: 1" = 600'
SHEET: B16 / 24
FILE No.: SJ-11-20-11

SAFETY PAYS

FUNCTIONAL ANALYSIS - VE PAYS







PROFILE - BIG DRY CREEK
LOOKING DOWNSTREAM
SCALE: VERTICAL - 1" = 10'-0"
HORIZONTAL - 1" = 400'-0"

NOTES:

1. FOR DETAIL "a", SEE SHEET No. B18.
2. FOR COMPLETE LOGS OF EXPLORATIONS IN THE BIG DRY CREEK AREA, SEE SHEET No. B9-B29
3. FOR LOCATION OF EXPLORATIONS, SEE SHEET No. B9.
4. ELEVATIONS REFER TO THE NATIONAL GEODETIC VERTICAL DATUM 1929 (NGVD)

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			GROUP SYMBOLS	TYPICAL NAMES
COARSE GRAINED SOILS 50% or more retained on the No. 200 sieve.	GRAVELS More than half of coarse fraction retained on the No. 4 sieve.	Clean Gravels	GW	Well-graded gravels, gravel-sand mixtures, little or no fines.
			GP	Poorly-graded gravels, gravel-sand mixtures, little or no fines.
		Gravels with fines	GM	Silty gravels, gravel-sand mixtures.
			GC	Clayey gravels, gravel-sand-clay mixtures.
	SANDS More than half of coarse fraction passing the No. 4 sieve.	Clean sands	SW	Well-graded sands, gravelly sands, little or no fines.
			SP	Poorly-graded sands, gravelly sands, little or no fines.
		Sands with fines	SM	Silty sands, sand-silt mixtures.
			SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS More than 50% passing the No. 200 sieve.	SILTS AND CLAYS	Liquid Limit below 50%	ML	Inorganic silts and very fine sands, rock flour, silty fine sands, or silts. Plasticity below "A" line.
			CL	Inorganic clays, gravelly clays, sandy clays, lean clays. Plasticity above "A" line.
			OL	Organic silts and organic clays. Plasticity below "A" line.
		Liquid Limit 50% and above	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts. Plasticity below "A" line.
			CH	Inorganic fat clays. Plasticity above "A" line.
			OH	Organic clays or organic silts. Plasticity below "A" line.
Highly organic soils			Pt	Peat, organic content greater than 60%.

LEGEND:

- 4R-1(100'R) — OFFSET DISTANCE TO RIGHT OF CENTERLINE EXISTING DAM
- BORING No.
- TOP OF SOIL
- SC — SOIL CLASSIFICATION PER UNIFIED SOILS CLASSIFICATION SYSTEM
- 17 NOV. 82 — GROUNDWATER DEPTH & DATE OF RECORD
- BOTTOM OF RECORD
- INSPECTION TRENCH
- ORIGINAL FOUNDATION
- PROPOSED TOP OF DAM
- EXISTING EMBANKMENT
- BEDROCK
- F — NO UNIFIED SOILS CLASSIFICATION AVAILABLE
- TOE OF EXPANDED DAM

GRAPHIC SCALES
ENGINEER SCALE
(H) 1" = 400' 0 200' 400' 800' 1200' 1600' 2000'
(V) 1" = 10' 0 5' 10' 20' 30' 40' 50'

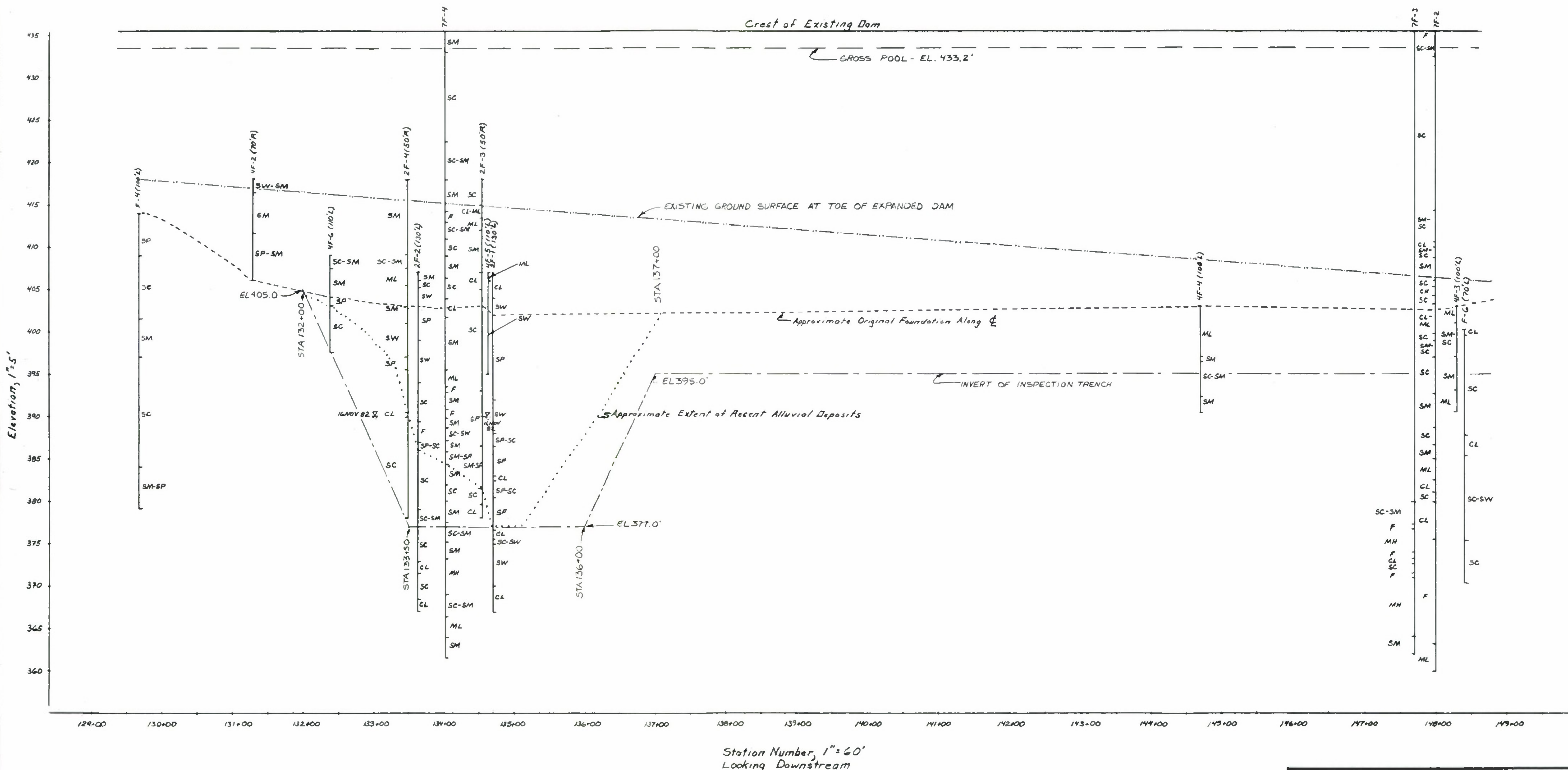
REVISION	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

REDBANK AND FANCHER CREEK, CALIFORNIA
BIG DRY CREEK
BIG DRY CREEK DAM
SOIL PROFILE

DESIGNED: K. Swanson
DRAWN: A. Lovato
CHECKED: O. Anderson
SUBMITTED: CHIEF, SOILS DESIGN SECTION
DATE APPROVED: 1/22/86
SCALE:
SHEET B17 / 25
FILE No. SJ-11-20-11
SPEC. No.

SAFETY PAYS



GRAPHIC SCALES

HORIZONTAL: 1"=60' — 0 30' 60' 120' 180' 240' 300'

VERTICAL: 1"=5' — 0 5' 10' 15' 20' 25'

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

REDBANK AND FANCHER CREEKS, CALIFORNIA
BIG DRY CREEK

BIG DRY CREEK DAM
SOIL PROFILE
DETAIL "a"

DRAWN: K. Swanson
CHECKED: D. Anderson
SUBMITTED: CHIEF, SOILS DESIGN SECTION

SHEET 818 / 26
FILE No. SJ-11-20-11

IF-1 VERTICAL

PRESSURE TESTS | RECOVERY % WATER CORE (100 0 100) — 35.6 G.P.M. at 23 P.S.I.

N 566,454.33 E 1,006,941.60

DEPTH

- 0.0 (1) (1) RESIDUAL SOIL, silty sand, reddish-brown
- 2.15 (2) (2) MICA SCHIST, dark-grey, fine grained, soft, highly fractured with heavy iron oxide staining on fracture surfaces, some clay on fracture surfaces
- 3.36 (3)
- 6.35 (4)
- 7.0 (5)
- 8.2 (6) (3) Fracture surfaces coated with quartz, iron oxide stained
- 13.3 (7) (4) 0.1-foot zone with clay coating on fracture surfaces
- (5) 0.1-foot clay coated fracture
- 16.3 (8) (6) 0.5-foot zone of intensely fractured rock
- (7) Body of rock is fresh to very slightly weathered, fractures heavily iron oxide stained
- 25.0 (8) Fracture surface coated with quartz, iron oxide stained

AVERAGE CORE RECOVERY 92^{3} %

IF-5 VERTICAL

PRESSURE TESTS | RECOVERY % WATER CORE (100 0 100) — NOT PRESSURE TESTED — NOT GAUGED

N. 566,402.13 E. 1,806,607.45

DEPTH

- 0.0 (1) (1) RESIDUAL SOIL, sandy silt, tan, damp, estimated 70-80% fines, 20-30% very fine to fine sand with scattered fragments of highly weathered
- 3.5 (2) (2) MICA SCHIST, low plaxtic fines
- 7.0 (3) (3) As above, tan to grayish tan, some clay
- 10.0 (4) (4) RESIDUAL SOIL, sandy silt, tanish-gray, damp, estimated 60-70% fines, 30-40% very fine to medium angular to subangular sand; contains fragments of MICA SCHIST, fragments are grey, fine grained, moderately soft to moderately hard, moderately weathered, strongly foliated
- 14.33 (5)
- 19.15 (6) (5) RESIDUAL SOIL, silty sand, gray to tanish-gray, damp, estimated 60-70% very fine to coarse angular sand, 30-40% medium plastic fines, fragments of moderately weathered MICA SCHIST
- 23.95 (7)
- 24.63 (8)
- (6) MICA SCHIST, gray to dark grey, fine grained, very hard, strongly foliated, intensely fractured, contains iron oxide stained quartz vein parallel to core axis, iron oxide stained fracture surfaces
- (7) As above
- (8) As above

AVERAGE CORE RECOVERY 58^{2} %

IF-2 VERTICAL

PRESSURE TESTS | RECOVERY % WATER CORE (100 0 100) — 0.0 G.P.M. at 18 P.S.I.

N 566,311.02 E 1,807,143.11

DEPTH

- 0.0 (1) (1) RESIDUAL SOIL, decomposed mica schist, micaceous silt, tan, dense, moist, est. 75% silt, 25% mica and sand, few rock fragments, nonplastic
- 10.0 (2) (2) MICA SCHIST, light brown to tan, fine grained, very soft, decomposed, washes away during drilling
- 17.3 (3) (3) Same as above with iron oxide staining
- 19.2 (4) (4) MICA SCHIST, dark grayish-brown, fine grained, very soft, highly weathered to decomposed, iron oxide stained, intensely fractured
- 24.6

AVERAGE CORE RECOVERY 44^{9} %

IF-6 VERTICAL

PRESSURE TESTS | RECOVERY % WATER CORE (100 0 100) — NOT PRESSURE TESTED — NOT GAUGED

N 562,970.2 E 1,804,618.01

DEPTH

- 0.0 (1) (1) RESIDUAL SOIL, sandy clay, light tan, damp, very fine to coarse grained sand, moderately plastic fines, scattered fragments of highly weathered MICA SCHIST to 1/4-inch
- 4.1 (2) (2) As above
- 9.0 (3) (3) As above, moist
- 13.0 (4) (4) MICA SCHIST, highly weathered
- 17.0 (5) (5) As above, moderately weathered
- 18.0 (6)
- 20.0 (7) (6) MICA SCHIST, fine grained, moderately soft, iron oxide stain on fracture surfaces slightly clay coated
- 22.2 (8)
- 23.3 (7) As above
- (8) As above

AVERAGE CORE RECOVERY 97^{3} %

IF-3 VERTICAL

PRESSURE TESTS | RECOVERY % WATER CORE (100 0 100) — PACKER WOULD NOT SEAL — NOT GAUGED

N 567,442.51 E 1,807,736.72

DEPTH

- 0.0 (1) (1) RESIDUAL SOIL, micaceous silt, light brown to tan, fine grained with scattered rock fragments to 2-inches, moist, estimated 70% fines, 30% rock fragments, fines nonplastic to slightly plastic
- 3.35 (2) (2) MICA SCHIST, grayish-brown, fine grained, very soft to soft, iron oxide stained, decomposed to highly weathered, contains scattered fragments and veins of intensely fractured and iron oxide stained quartz
- 10.2 (3)
- (3) MICA SCHIST, gray with some iron oxide staining, fine grained, very soft to soft
- 19.8 (4) (4) MICA SCHIST, greenish-gray to gray, iron oxide stained on fresher pieces, very soft to soft, altered to clay in some places
- 22.7 (5)
- 27.7 (6) (5) MICA SCHIST, brownish-gray to brown, fine grained, soft to moderately soft, strongly foliated at 25 to 27 degrees from core axis, alternating bands of black and gray, highly fractured
- 31.7 (7) (6) As above, altered to clay in some places
- 33.5 (8) (7) MICA SCHIST, grayish-brown, fine grained, soft to moderately soft, highly fractured, contains scattered fragments of highly fractured and iron oxide stained quartz
- 42.43 (9) (8) SCHIST, dark gray, very fine grained, hard, moderately to highly fractured, fractures healed and iron oxide stained in places
- 47.5 (10)
- 30.23 (9) SCHIST, gray to dark gray, aphanitic to very fine grained, very hard, highly to intensely fractured, abundant fractures healed with iron oxide stained material
- (10) As above

AVERAGE CORE RECOVERY 64^{9} %

IF-7 VERTICAL

PRESSURE TESTS | RECOVERY % WATER CORE (100 0 100) — NOT PRESSURE TESTED — NOT GAUGED

N 582,788.81 E 1,804,768.41

DEPTH

- 0.0 (1) (1) ALLUVIUM, sandy clay, black, fine to coarse grained, medium plastic
- 1.0 (2) (2) ALLUVIUM, sandy silt, reddish-light brown, moist, very fine to coarse grained
- 3.0 (3) (3) RESIDUAL SOIL, sandy silt, light tan, very fine to coarse grained, contains subangular fragments of of weathered MICA SCHIST to 1-1/2 inches
- 13.0 (4) (4) As above, damp
- 14.2 (5) (5) As above, fine grained fragments of moderately weathered MICA SCHIST
- 16.5 (6)
- 17.3 (7) (6) RESIDUAL SOIL, sandy clayey silt, dark brown, damp, very fine to coarse grained with moderately weathered, subangular fragments of MICA SCHIST
- 21.4 (8) (7) MICA SCHIST, fine to medium grained, very soft to moderately soft, fractures coated with iron oxide staining
- 25.0 (8) As above, some green mineral on fracture surfaces broken or healed, highly iron oxide stained, uniform texture throughout core

AVERAGE CORE RECOVERY 74^{1} %

IF-4 VERTICAL

PRESSURE TESTS | RECOVERY % WATER CORE (100 0 100) — NOT PRESSURE TESTED — NOT GAUGED

N 568,244.63 E 1,806,588.69

DEPTH

- 0.0 (1) (1) RESIDUAL SOIL, sandy silt, tan to light brown, very fine to coarse grained, damp, estimated 70% fines, 30% very fine to coarse sand, low to medium plastic fines, contains fragments of highly weathered MICA SCHIST to 1-inch
- 8.5 (2) (2) As above, contains some fragments of soft clay
- 10.3 (3) (3) RESIDUAL SOIL possibly FAULT GOUGE, sandy clay, greenish-brown, moist, estimated 80% soft clay, 20% very fine to coarse angular sand, sand composed of fragments of MICA SCHIST
- 14.0 (4)
- 16.0 (5) (4) As above, brownish-gray, saturated
- 20.5 (6) (5) RESIDUAL SOIL possibly GOUGE, sandy clay, very loose, saturated, estimated 90-95% clay, 5-10% very fine to medium angular sand
- (6) As above
- (7) MICA SCHIST, dark gray, fine grained, very hard, highly to intensely fractured, clay filled fractures, some fractures stained with iron oxide
- 31.0 (7)
- 36.23

AVERAGE CORE RECOVERY 66^{6} %

VERTICAL SCALE: 1" = 9'

EXPLANATION OF SYMBOLS

Soils conform to Military Standard 619B "UNIFIED SOILS CLASSIFICATION SYSTEM"

CL

FRACTURES
- Oriented with axis of core
- Core too highly fractured to reassemble
- Interval of core loss in run

WEATHERING
- High
- Moderate
- Slight

NOTES:

- (a) Staining on fractures and in body of rock is iron oxide staining.
- (b) Core recovery based only on interval of hole cored.
- (c) F.C. denotes field classification.
- (d) All core size is NX or NX wireline.
- (e) Drill hole inclinations are measured from horizontal.
- (f) (3) Number in parentheses corresponds to number shown on graphic log.
- (g) Very hard - cannot be scratched with a knife.
- (h) Hard - difficult to scratch with a knife.
- (i) Moderately hard - can be scratched easily with a knife.
- (j) Moderately soft - can be carved with a knife.
- (k) Soft - can be gouged with a penny.
- (l) Very soft - can be gouged with fingernail.

GRAPHIC SCALE

SCALE IN FEET 0' 3' 10' 20' 30' 40' 50'

REVISION	DATE	DESCRIPTION	BY	BY

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DESIGNED: K. E. JORGENSEN
DRAWN: R.A. KELLEY
CHECKED: M.O. BOYO

REDBANK AND FANCHER CREEKS, CALIFORNIA
BIG DRY CREEK

BIG DRY CREEK DAM

LOGS OF CORED DRILL HOLES

IF-1 thru IF-7

SUBMITTED: Robert L. Just — CHIEF, GEOLOGY SECTION
DATE APPROVED: 22 Jan 86
SCALE:
SPEC. No.
SHEET B 19 / 27
FILE No. SJ-11-20-11

2 F - 1

EL 407.0'

Depth	Class	N	GR	SA	FI	LL	PI	MC
0	CL		-	-	-	-	-	-
2.0'	(CL)		-	-	-	-	-	-
3.0'	SW	11	5	94	3	-	NP	1
5.0'	SP	10	20	79	2	-	NP	-
9.5'	(SP)	14 / 20	-	-	-	-	-	-
11.0'	SC-SP	17	-	-	-	-	-	-
12.5'	(SP)	19	-	-	-	-	-	-
15.0'	SW	25	27	99	4	-	-	23
16.5'	(SM)	19	-	-	-	-	-	-
19.0'	SP-SC	24	-	-	-	-	-	-
20.5'	(SP)	20	-	-	-	-	-	-
24.0'	CL	12	-	42	58	35	17	-
24.5'	SP-SC	16	-	-	-	-	-	-
26.5'	(SP-SC)	19	-	-	-	-	-	-
30.5'	CL		-	-	-	-	-	-
31.3'	SC-SW	13	11	78	11	-	-	-
32.0'	(SW)	21	-	-	-	-	-	-
37.0'	CL	44	-	45	55	31	10	13
33.0'	CL	24	-	-	-	-	-	-
40.0'								

Water level 18.0'

- *SANDY CLAY, very dark gray-brown, damp, est. 55% medium plasticity fines, est. 45% fine to medium grained sand, micaceous
- SANDY CLAY, as above (F.C.)
- SAND, light tan, very fine to coarse, subrounded to subangular grained sand, gravel to 1/2" maximum size, micaceous
- GRAVELLY SAND, light tan, moist, very fine to coarse, subrounded to subangular grained sand, gravel to 3/4" maximum, micaceous
- GRAVELLY SAND, as above (F.C.)
- *CLAYEY SAND, light brown-gray, damp, est. 85% medium to coarse, subrounded to subangular grained sand, est. 10% hard angular gravel to 3/8" maximum, est. 5% medium plasticity fines
- GRAVELLY SAND, as above, except gravel to 3/4" maximum (F.C.)
- GRAVELLY SAND, light tan, very fine to coarse, subrounded to subangular grained sand, gravel to 1" maximum
- SILTY GRAVELLY SAND, light tan to brown, fine to coarse subrounded to subangular grained sand, micaceous, quartz grains (F.C.)
- *CLAYEY GRAVELLY SAND, dark brown, damp, est. 73% medium to coarse grained sand, est. 20% hard, angular gravel to 3/4" maximum, est. 5% medium plasticity fines
- GRAVELLY SAND, tan to black, wet, fine to coarse, subrounded to subangular grained sand, less gravel than above, micaceous, quartz grains (F.C.)
- SANDY CLAY, light brown, damp, very fine to medium grained sand, micaceous
- *CLAYEY GRAVELLY SAND, est. 75% medium grained sand, est. 20% hard angular gravel to 5/4" maximum, est. 5% low plasticity fines
- CLAYEY SAND, light brown, damp, very fine to fine grained sand, medium plasticity fines, micaceous (F.C.)
- *SANDY CLAY, grey brown, damp, est. 65% low plasticity fines, est. 55% fine to medium grained sand
- CLAYEY SAND, tan, wet, very fine to coarse, subrounded to subangular grained sand, gravel to 3/4" maximum, micaceous
- GRAVELLY SAND, tan, wet, fine to coarse, subrounded to subangular grained sand, micaceous (F.C.)
- SANDY CLAY, reddish-brown, very fine to medium grained sand, micaceous
- *SANDY CLAY, light yellow-brown, damp, est. 30% medium plasticity fines, est. 40% fine to medium grained sand

Nov 1983

2 F - 2

EL 407.0'

Depth	Class	N	GR	SA	FI	LL	PI	MC
0	(SM)	5	-	-	-	-	-	-
1.0'	(SC)		-	-	-	-	-	-
1.5'	(SW)		-	-	-	-	-	-
2.0'	SW	25	5	92	5	-	NP	2
3.5' / 4.0'	(SW)		-	-	-	-	-	-
	SP	19	-	-	-	-	-	-
3.5'	(SP)	29	-	-	-	-	-	-
9.0'	SW	39	17	79	5	-	-	-
9.5'	(SW)	29	-	-	-	-	-	-
13.0' / 13.5'	SC	15	-	54	92	25	8	8
	(SC)	11	-	-	-	-	-	-
16.0'	SC	14	-	-	-	-	-	-
17.5'	(F)	13	-	-	-	-	-	-
20.0'	SP-SC		-	-	-	-	-	-
21.0' / 21.5'	SC	23	-	56	44	23	4	20
22.0'	(SC)	49	19	51	33	50	14	13
23.5'	SC	56	-	-	-	-	-	-
25.5'	(SC)	30	-	-	-	-	-	-
26.0'	SC-SM	75	-	72	23	26	7	16
30.0'	SC	30	-	-	-	-	-	-
52.0'	SC	45	-	-	-	-	-	-
34.0'	CL	20	-	25	77	40	13	31
35.5'	(SC)	56	-	-	-	-	-	-
36.5'	CL	21	-	-	-	-	-	-
40.0'								

Water level 13.0'

- SILTY SAND, dark brown, damp, est. 75% very fine to medium grained sand, est. 25% fines, scattered gravel to 3/4" maximum (F.C.)
- CLAYEY SAND, reddish-brown, damp, very fine to fine grained sand, medium plasticity fines, micaceous (F.C.)
- GRAVELLY SAND, light gray, moist, fine to coarse, subrounded to subangular grained sand, micaceous, quartz grains (F.C.)
- SAND, light gray, very fine to coarse grained sand, gravel to 1/2" maximum
- GRAVELLY SAND, brownish-gray, damp, est. 50% fine to coarse, subrounded to subangular grained sand, gravel to 1/2" maximum, micaceous (F.C.)
- SAND, dark gray-brown, damp, est. 95% medium grained sand, est. 5% hard gravel to 5/8" maximum, a trace of fines
- SAND, as above (F.C.)
- GRAVELLY SAND, brownish-gray, damp, very fine to coarse, subrounded to subangular grained sand, gravel to 3/4" maximum, micaceous
- GRAVELLY SAND, tannish-brown, damp, fine to coarse subrounded to subangular grained sand, micaceous, quartz grains (F.C.)
- CLAYEY SAND, dark brown, very fine to medium grained sand, micaceous
- CLAYEY SAND, as above
- *CLAYEY SAND, brown, damp, est. 65% graded sand, est. 35% medium plasticity fines
- SAMPLE LOST (F.C.)
- *SAND, gray-brown, damp, est. 95% medium grained sand, est. 5% non to low plasticity fines, trace of gravel
- CLAYEY SAND, light reddish-brown with iron oxide staining, very fine to medium grained sand, micaceous, carbonaceous
- CLAYEY SAND, as above, except scattered gravel to 1" maximum (F.C.)
- GRAVELLY CLAYEY SAND, light reddish-brown with iron oxide staining, very fine to medium grained sand, gravel to 1-1/2" maximum
- *CLAYEY SAND, pale brown, damp, est.55-90% medium grained sand, est. 40-45% medium plasticity fines
- CLAYEY SAND, light reddish-brown with iron oxide staining, very fine to fine grained sand, low plasticity fines, micaceous, carbonaceous (F.C.)
- SILTY CLAYEY SAND, light reddish-brown with iron oxide staining, very fine to medium grained sand
- *CLAYEY SAND, brown, damp, est. 35% medium grained sand, est. 35% high plasticity fines
- *CLAYEY SAND, brown, damp, est. 60% medium grained sand, est. 40% medium plasticity fines
- SANDY CLAY, reddish-brown, very fine to medium grained sand
- CLAYEY SAND, reddish-brown, moist, very fine to coarse subangular grained sand, low plasticity fines, micaceous, carbonaceous (F.C.)
- *SANDY CLAY, dark brown, damp, est. 55% medium plasticity fines, est. 45% medium grained sand

Nov 1983

STANDARD PENETROMETER DESCRIPTIVE DATA

COHESIONLESS		COHESIVE	
Blows*	Relative Density	Blows*	Consistency
0-4	Very Loose	0-1	Very Soft
5-10	Loose	2-4	Soft
11-20	Firm	5-8	Firm
21-50	Very Firm	9-15	Stiff
31-50	Dense	16-50	Very Stiff
51+	Very Dense	51+	Hard

*Blows per 1.0 ft. of penetration of a 2-inch O.D. and 1 3/8-inch I.D. sampler driven by a 140-lb. hammer, 30-inch freefall.

2 F - 3

EL 418.0'

Depth	Class	N	GR	SA	FI	LL	PI	MC
0 / 1.0'	SC		-	55	45	32	10	10
3.0'	CL-ML	39	-	36	32	23	4	-
4.5'	(ML)	14	-	-	-	-	-	-
9.0'	SM	25	-	72	23	14	2	9
3.3'	(SM)	21	-	-	-	-	-	-
11.0'	SC	45	-	39	31	-	-	-
13.0'		38 / 21						
	SW-SC	24	3	36	6	-	-	3
		25 / 29						
23.0'	SC	30	-	-	-	-	-	-
25.0'		28						
	(SP)	55	-	-	-	-	-	-
30.0'	SP	34	3	95	2	-	NP	14
31.5'	(SP-SM)	29	-	-	-	-	-	-
39.5'	SC		7	77	16	39	22	19
39.2'	CL	35	-	-	-	-	-	-
40.0'								

Water level 28.0'

- *CLAYEY SAND, dark brown, damp, est. 70% medium grained sand, est.30% low to medium plasticity fines, trace of gravel
- CLAYEY SAND, tannish-brown, very fine to coarse grained sand, some subangular gravel to 1" maximum observed in field
- SANDY CLAY-SANDY SILT, light tan, dry, very fine to medium, subangular grained sand
- SANDY SILT, light tan, dry, subangular grained sand (F.C.)
- SILTY SAND, dark reddish-brown, very fine to medium grained sand
- SILTY SAND, as above (F.C.)
- CLAYEY SAND, reddish-brown, damp, very fine to medium grained sand, micaceous
- CLAYEY SAND, tannish-brown, very fine to medium subangular grained sand, gravel to 5/4" maximum, micaceous
- *CLAYEY SAND, brown, damp, est. 70% medium grained sand, est. 20% low plasticity fines, est. 10% hard angular gravel to 1/2" maximum
- GRAVELLY SAND, tan to brown, damp, fine to coarse subangular grained sand, gravel to 1/2" maximum, micaceous (F.C.)
- SAND, bluish-tan to light brown, very fine to coarse, subangular to subrounded grained sand, gravel to 1/2" maximum
- SILTY SAND, same as above, slight increase in amount of fines, gravel to 5/8" maximum
- CLAYEY SAND, reddish-brown with some iron oxide staining, very fine to coarse grained sand, gravel to 3/4" maximum, micaceous
- *SANDY CLAY, dark brown, damp, est. 55% medium plasticity fines, est. 45% fine to medium grained sand

Nov 1983

2 F - 4

EL 418.0'

Depth	Class	N	GR	SA	FI	LL	PI	MC
0			5	77	19	-	-	9
5.0'	SM	33	2	54	44	-	-	-
5.0'		16	-	36	34	-	-	-
6.5'	(SM)	17	-	-	-	-	-	-
9.0'	SC-SM	22	-	57	43	20	3	13
11.0'	ML	22	-	45	55	-	-	19
12.5'	(SM)	27	-	-	-	-	-	-
19.0'	SM	43	-	38	12	-	-	-
17.0'	SW	47	3	37	5	-	-	4
19.5'	(SW)	29	-	-	-	-	-	-
21.0'	SP-SM	24	-	-	-	-	-	-
22.5'	SW	19	14	61	5	-	-	7
24.5'	(SW)	21	-	-	-	-	-	-
27.8'	CL	21						
	SC		4	31	15	31	19	19
50.5'	(SC)	27 / 41	-	-	-	-	-	-
59.5'	SC	70	-	79	21	-	-	-
40.0'								

Water level 28.0'

- SILTY SAND, dark brown, very fine to coarse grained sand, gravel to 5/4" maximum, micaceous
- SILTY SAND, reddish-brown, dry on top, moist on bottom, very fine to medium grained sand, gravel to 3/3" maximum
- SILTY SAND, reddish-brown, moist, very fine to medium grained sand, micaceous
- SILTY SAND, as above, except very fine to coarse grained sand (F.C.)
- SILTY CLAYEY SAND, dark reddish-brown, very fine to medium grained sand
- SANDY SILT, reddish-brown, very fine to medium grained sand, scattered hard gravel to 1/2" maximum observed in field, highly cemented, micaceous
- SILTY SAND, as above, except very fine to coarse grained sand (F.C.)
- SILTY SAND, tan to light brown, damp, very fine to coarse subrounded grained sand, micaceous, quartz grains
- SAND, tan to light brown, very fine to coarse subrounded grained sand, gravel to 3/4" maximum, micaceous, quartz grains
- SAND, as above
- *SILTY SAND, grey-brown, damp, est. 95% medium grained sand, est. 5% non-plastic fines, trace of gravel
- SAND, very fine to coarse, subrounded to subangular grained sand, gravel to 5/4" maximum, micaceous
- GRAVELLY SAND, as above (F.C.)
- SANDY CLAY, grey to light tan, wet
- CLAYEY SAND, dark red to brown, very fine to coarse grained sand, gravel to 3/8" maximum, micaceous
- CLAYEY SAND, as above (F.C.)
- CLAYEY SAND, as above

Nov 1983

Vertical Scale: 1" = 4'

LEGEND:

- N — Number of Blows of Standard Penetrometer.
- R — Refusal with Standard Penetrometer.
- A — Attempt with Standard Penetrometer.
- ▽ — Water Level.

NOTES:

1. Borings 2F-1 thru 2F-4 were drilled with a Mobile B-53 drill rig, equipped with an 8" hollow stem auger on 16 November thru 17 November 1985.
2. For additional logs of borings and trenches, see sheet Nos. B 9-B 29.
3. For location of borings, see sheet No. B 16.
4. Groundwater was encountered during drilling.
5. Refusal of the Standard Penetrometer is as one of the following:
   a. 25 blows for 1" or less advancement of sampler; or
   b. 50 blows for 1" to 3" advancement of sampler.
6. Attempt with the Standard Penetrometer is defined as refusal within the first 6"; seating penetration.
7. For additional notes and legend, see sheet. B 22.

GRAPHIC SCALE

1" = 4' — 0, 1'2', 4', 6', 12', 13', 20'

REVISION	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DESIGNED: K. Swanson
DRAWN: K Wahl
CHECKED: D Anderson
SUBMITTED: Chief, Soils Design Section

REDBANK AND FANCHER CREEKS, CALIFORNIA
BIG DRY CREEK
BIG DRY CREEK DAM
LOGS OF EXPLORATIONS
2F-1 thru 2F-4

DATE APPROVED: 4/29/86
SHEET B 20 / 28
FILE No. SJ-11-20-11

2F-10

Depth	Class.	#	GR	SA	FI	LL	PI	MC	Description
0									0 to 35' not sampled
35.0'		18	1	54	45	22	4	-	CLAYEY SAND, brownish-black, moist, very fine to fine grained sand, non-cemented, organic odor and material (roots)
37.5'	SM-SC	14	3	87	34	20	8	12	CLAYEY SAND, light brown, very fine to medium grained sand, low plasticity fines, non-cemented
39.4'	(SM)	21	-	-	-	-	-	-	SILTY SAND, dark brown to reddish-brown, low plasticity fines, slightly cemented, some organic material
∇41.0'	(ML)	42	-	-	-	-	-	-	SANDY SILT, dark brown, damp to moist, est. 60-70% medium plasticity fines, est. 30-40% very fine grained sand, non-cemented, organic odor
43.0'	SM	11	4	58	38	18	1	-	SILTY SAND, brown, wet to saturated, very fine to fine grained sand, low plasticity fines, non-cemented
46.3'		11	-	-	-	-	-	-	SILTY SAND, orangish-brown, moist, est. 70-80% very fine to fine grained sand, est. 20-30% medium plasticity fines, non-cemented
48.3'	(SM)	24, 29, 25	-	-	-	-	-	-	SILTY SAND, greyish brown with streaks of black and green, damp to moist, est. 75-85% very fine to fine grained sand, scattered medium to coarse subrounded grained sand, est. 15-25% fines, non-cemented
52.5'	(SC-SM)	88	-	-	-	-	-	-	GRAVELLY SILTY SAND, reddish-brown with varied colored gravel, est. 70-80% very fine to medium grained sand, scattered coarse grained sand, 10-20% medium plasticity fines, est. 10% angular gravel, non-cemented
55.1'		85	-	-	-	-	-	-	SILTY SAND, greyish-brown with streaks of black and green, damp to moist, est. 75-95% very fine to fine grained sand, scattered medium to coarse subrounded grained sand, est. 15-25% fines, non-cemented
57.1'	(SM)	50, 32	-	-	-	-	-	-	SILTY SAND, reddish-brown with varied colored sand, damp to moist, est 80-90% very fine to coarse angular arkosic sand, 10-20% low to medium plasticity fines, non-cemented, scattered fragments of highly weathered granitics
60.5'									

2F-11

Depth	Class.	GR	SA	FI	LL	PI	MC	Description
0								0 to 40.0' not sampled
40.0'	(SM)	-	-	-	-	-	-	SILTY SAND
43.0'		0	81	59	17	1	17	SILTY SAND, brown, very fine to fine grained sand, low plasticity fines, loose, non-cemented (original creek bed material)
45.5'	SM	18	80	22	-	NP	15	SILTY SAND, as above
47.2'	(SC-SM)	-	-	-	-	-	-	GRAVELLY SILTY SAND, brown, wet, est. 65-75% sand, est. 15-25% fines, est. 5-10% gravels
47.8'								

Vertical Scale: 1" = 2'

2F-12

Depth	Class.	#	Description
0			0 to 42.0', not sampled
∇40.0'			
42.0'	(SM)	28	SILTY SAND, dark brown to brownish-black, damp to moist, est. 75-85% very fine to fine grained sand, est. 15-25% low plasticity fines, non-cemented
44.1'		22	SILTY SAND, brown, wet to saturated, est. 75-85% very fine to fine grained sand, 15-25% low plasticity fines, non-cemented
45.5'	(SC-SM)		GRAVELLY CLAYEY SAND, brown, est. 60-70% very fine to coarse angular grained sand, est. 20% fines, est. 10% angular gravel to 1/2" size, non-cemented weathered schist and granitic gravel
47.0'	(SC)	37	CLAYEY SAND, reddish-brown with streaks of black material, damp to moist, 75-95% very fine grained sand est. 15-25% fines, non-cemented
47.5'			

NOTES:

1. For location of borings, see Sheet No. B6.
2. For additional notes and legend, see Sheet No. B22.
3. For additional logs of boring in the Big Dry Creek area, see Sheet No. B9-B29.

GRAPHIC SCALE

1" = 2' 0 1' 2' 4' 6' 8' 10'

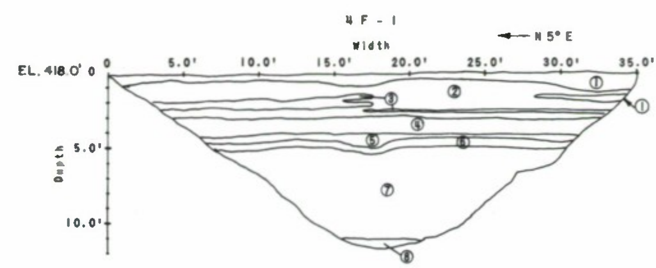
REVISION	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DESIGNED: K. Swanson
DRAWN: K Wahl
CHECKED: D. Anderson
SUBMITTED: CHIEF, SOILS DESIGN SECTION

REDBANK AND FANCHER CREEKS, CALIFORNIA
BIG DRY CREEK
BIG DRY CREEK DAM
LOGS OF EXPLORATIONS
2F-10 thru 2F-12

DATE APPROVED: | SCALE: | SHEET B 21 | 29 | FILE No. SJ-11-20-11 | SPEC. No.



Field Density = 130.2 PCF (γ_d = 112.2 PCF, W_o = 18.0%)

Scale: 1" = 5'

① SILTY SAND (SM), orangish-brown, 12% moisture content, 80% very fine to coarse grained sand, 38% low to medium plasticity fines, 2% gravel to 1" maximum, loose, non-cemented

② SANDY CLAY (CH), dark grey, dry, 76% high plasticity fines (LL = 50, PI = 39), 24% very fine to medium grained sand, abundant organic material (roots, etc.), non-cemented

③ SANDY SILT (ML), tan, dry, est. 80% non- to low plasticity fines, est. 40% very fine to fine grained sand, stiff, non-cemented (F.C.)

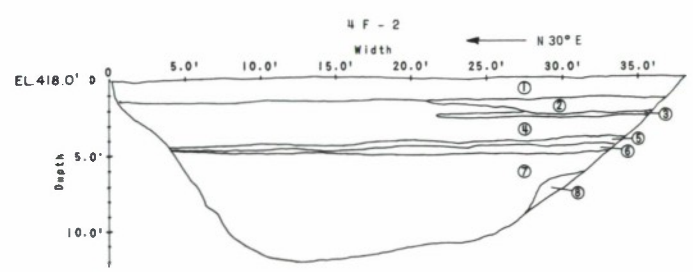
④ SANDY SILT (ML), tan, dry, 52% non- to low plasticity fines, 48% very fine to medium grained sand, abundant voids to 1/16" (from roots), G_s = 2.74

⑤ SANDY SILT (ML), dark brick red, dry, est. 70% medium plasticity fines, est. 30% very fine to fine grained sand, abundant organic material (roots, etc.), very stiff, non-cemented (F.C.)

⑥ CLAYEY SAND (SC), reddish-brown, dry, est. 60% very fine to fine grained angular to subangular sand, est. 40% very stiff clay, brittle, non-cemented (F.C.)

⑦ SILTY SAND (SM), brown with iron oxide staining, damp, 58% very fine to medium grained angular to subangular sand, 42% low to medium plasticity fines, firm, non-cemented, numerous stringers of white material

⑧ SANDY CLAY (CL), grey, dry, est. 80-90% fines, est. 10-20% very fine grained sand, very stiff, non-cemented, numerous stringers of white material (F.C.)



Field Density = 124.7 PCF (γ_d = 111.8 PCF, W_o = 11.7%)

Scale: 1" = 5'

① SILTY SAND (SW-SM), orangish-brown, 8% moisture content, 87% very fine to coarse grained subangular to rounded sand, 11% low plasticity fines, 2% gravel to 3/8" maximum, loose, non-cemented

② SILTY SAND (SM), brown, damp, 72% very fine to medium grained sand, 28% non-plastic fines, soft, non-cemented, G_s = 2.78

③ SANDY SILT (ML), dark brown, est. 80-70% low plasticity fines, est. 30-40% very fine grained sand, soft, non-cemented (F.C.)

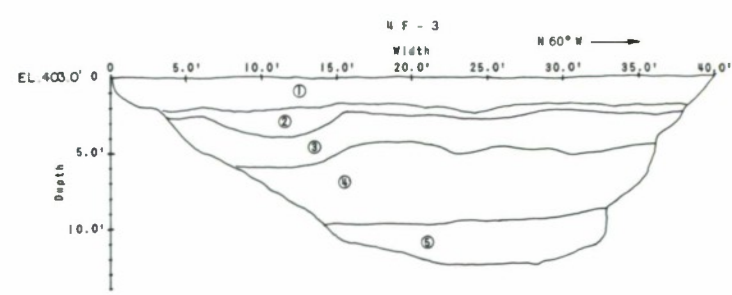
④ SILTY SAND (SM), orangish-brown, dry to damp, 78% very fine to medium grained sand, 22% non- to low plasticity fines, loose to firm, non-cemented

⑤ SILTY SAND (SM), as above except dark brown (F.C.)

⑥ SILTY SAND (SM), as above except brown to light brown (F.C.)

⑦ SILTY SAND (SM), dark brown, 14% moisture content, 55% very fine to medium grained sand, 45% low plasticity fines (LL = 28, PI = 3), non-cemented, highly micaceous

⑧ SILTY SAND (SP-SM), light brown to grey, 4% moisture content, 93% very fine to fine grained sand, 7% fines, very loose, non-cemented, micaceous, abundant magnetite, heavily cross-bedded



Field Density = 121.1 PCF (γ_d = 104.2 PCF, W_o = 16.2%)

Scale: 1" = 5'

① SANDY SILT (ML), light brown to dark brown, 55% low to medium plasticity fines, 45% very fine to medium grained sand, soft to firm, non-cemented, G_s = 2.74

② SILTY CLAYEY SAND (SM-SC), orangish-brown to reddish-brown, 24% moisture content, 65% very fine to coarse grained sand, 35% low plasticity fines (LL = 22, PI = 4), stiff to very stiff, moderately cemented, abundant amount of white material occurring as stringers through the unit and as coatings on broken pieces

③ SILTY CLAYEY SAND (SM-SC), orangish-brown, damp, 98% very fine to medium grained angular to subangular sand, 34% low plasticity fines, firm, slightly cemented, G_s = 2.74

④ SILTY SAND (SM), brown, 15% moisture content, 80% very fine to medium grained angular to subrounded sand, 20% non- to low plasticity fines, loose, non-cemented, micaceous

⑤ SANDY SILT (ML), brick red, moist, 93% medium plasticity fines, 57% very fine to medium grained sand, soft to firm, non-cemented, mica flakes

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			GROUP SYMBOLS	TYPICAL NAMES
COARSE GRAINED SOILS 50% or more retained on the No. 200 sieve.	GRAVELS More than half of coarse fraction retained on the No. 4 sieve.	Clean gravels	GW	Well-graded gravels, gravel-sand mixtures, little or no fines.
			GP	Poorly-graded gravels, gravel-sand mixtures, little or no fines.
		Gravels with fines	GM	Silty gravels, gravel-sand mixtures.
			GC	Clayey gravels, gravel-sand-clay mixtures.
	SANDS More than half of coarse fraction passing the No. 4 sieve.	Clean sands	SW	Well-graded sands, gravelly sands, little or no fines.
			SP	Poorly-graded sands, gravelly sands, little or no fines.
		Sands with fines	SM	Silty sands, sand-silt mixtures.
			SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS More than 50% passing the No. 200 sieve.	SILTS AND CLAYS	Liquid Limit below 50%	ML	Inorganic silts and very fine sands, rock flour, silty fine sands or silts. Plasticity below "A" line.
			CL	Inorganic clays, gravelly clays, sandy clays, lean clays. Plasticity above "A" line.
			OL	Organic silts and organic clays. Plasticity below "A" line.
		Liquid Limit 50% and above	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts. Plasticity below "A" line.
			CH	Inorganic fat clays. Plasticity above "A" line.
			OH	Organic clays or organic silts. Plasticity below "A" line.
Highly organic soils			Pt	Peat, organic content greater than 60%.

LEGEND:

- GR — Gravel, percent by weight passing 3-inch sieve and retained on the No. 4 sieve.
- SA — Sands, percent by weight passing the No. 4 sieve and retained on the No. 200 sieve.
- FI — Fines, percent by weight passing the No. 200 sieve.
- LL — Liquid Limit.
- PI — Plasticity Index (Liquid Limit Minus Plastic Limit).
- MC — Field Moisture Content in Percent of Dry Weight.
- (F.C.) — Visual Field Classification.
- * — Laboratory Visual Classification.
- ▽ — Water Level.
- G_s — Specific Gravity (Minus no. 4)
- γ_d — Dry Unit Weight.

NOTES:

1. Classifications are in accordance with the Unified Soils Classification System (ASTM D-2487).
2. All sieve sizes on the chart are U.S. Standard.
3. The terms "silt" and "clay" are used respectively to distinguish materials exhibiting lower plasticity from those with higher plasticity. The minus No. 200 sieve material is silt if the liquid limit and plasticity index plot below the "A" line on the plasticity chart (ASTM D-2487) and is clay if the liquid limit and plasticity index plot above the "A" line on the chart.
4. Borderline Classification; Soils possessing characteristics of two groups are designated by combinations of group symbols. For example GW-GC, a well-graded gravel-sand mixture with a clay binder.
5. For Location of Trenches see Sheet No. B16.
6. For additional Logs of Borings and Trenches see Sheets B 9 - B 29.
7. Trenches 4F-1 thru 4F-3 were dug with an International 260A backhoe, equipped with a 24" bucket from 12-16 November 1982.
8. Groundwater was encountered during trenching.
9. Field densities determined were taken at the trench bottoms using Sand Cone Density Tests. Measured water contents and calculated dry unit weights are shown in parentheses.

GRAPHIC SCALE

1" = 5'   0   5'   10'   15'   20'   25'

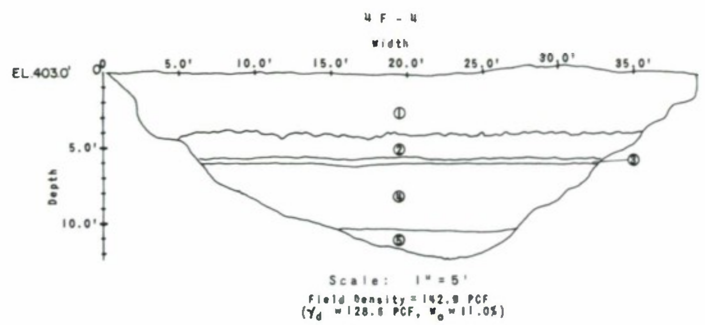
REVISION	DATE	DESCRIPTION	BY	BY
△				
△				

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DESIGNED: K. Swenson
DRAWN: K. Wahl
CHECKED: D. Anderson

REDBANK AND FANCHER CREEKS, CALIFORNIA
BIG DRY CREEK
BIG DRY CREEK DAM
LOGS OF EXPLORATIONS
4F-1 thru 4F-3

SUBMITTED: Clark E. [signature] CHIEF, SOILS DESIGN SECTION
DATE APPROVED: 4/22/86
SCALE:
SPEC. No.
SHEET B22 / 30
FILE No. SJ-11-20-11



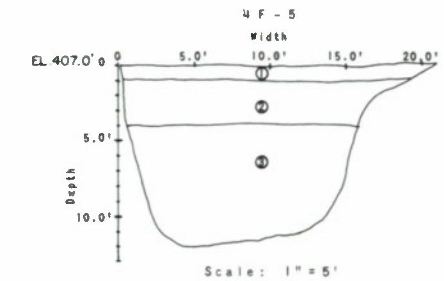
① SANDY SILT (ML), dark brown to light brown, dry to damp, 69% medium plasticity fines, 31% very fine to medium grained sand, organic material (roots, etc.), firm to stiff, non-cemented

② SILTY CLAYEY SAND (SC-SM), tan to orangish-brown, 5% moisture content, 56% very fine to medium grained sand, 44% low plasticity fines (LL = 19, PI = 8), organic material (roots, etc.), firm to stiff, slightly cemented, G_s = 2.72

③ SILTY SAND (SM), brick red, dry, 67% very fine to coarse grained angular to subrounded sand, 31% medium plasticity fines, 2% gravel to 1" maximum, dense to very dense, moderately cemented, contact between materials 2 and 3 appears to be gradational

④ SILTY CLAYEY SAND (SM-SC), orangish-brown to reddish-brown, 15% moisture content, 58% very fine to medium grained sand, 42% low plasticity fines (LL = 24, PI = 9), loose to firm, non-cemented

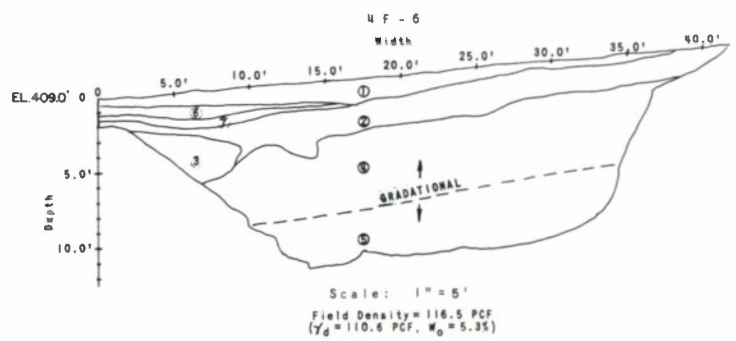
⑤ SILTY SAND (SM), orangish-brown to reddish-brown, 12% moisture content, 56% very fine to medium grained angular to subrounded sand, 44% medium to high plasticity fines, firm, non-cemented



① SANDY SILT (ML), dark brown to brown, moist to wet, est. 80-90% medium plasticity fines, est. 10-20% very fine grained sand, organic material (roots, etc.), soft, non-cemented, micaceous (F.C.)

② SAND (SW), tan to light brown, moist, 87% very fine to coarse grained subangular to rounded sand, 12% gravel to 3/4" maximum, 1% fines, very loose, non-cemented, abundant crossbedding with zones of coarse material, magnetite

③ SAND (SW), light brown, 4% moisture content, 87% very fine to coarse grained subangular to round sand, 10% rounded to well rounded gravel to 1-1/2" maximum (homogeneous distribution), 3% fines, G_s = 2.79



① SILTY GRAVELLY SAND (SP-SM), brown, damp to moist, 51% very fine to coarse grained subangular to round sand, 35% fine to coarse, subrounded to rounded gravel, 9% cobbles, 5% non- to low plasticity fines, organic material (small roots, etc.), very loose to loose, non-cemented, highly micaceous

② SILTY SAND (SM), brownish-gray to tan, 3% moisture content, 67% very fine to medium grained sand, 33% non-plastic fines, firm, non-cemented

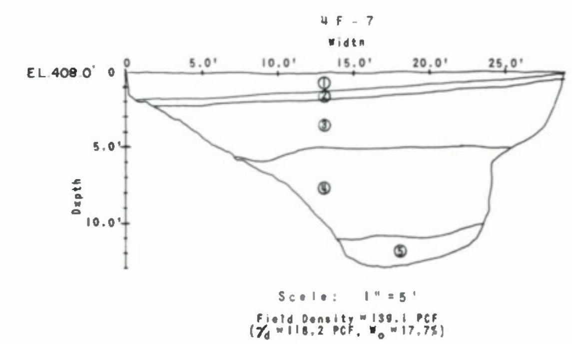
③ SAND (SP), tan, damp, 99% very fine to medium grained sand, 1% fines, very loose, non-cemented, abundant magnetite in thin horizontal layers

④ CLAYEY SAND (SC), orangish-brown, 5% moisture content, 65% very fine to medium grained subangular to subrounded sand, 34% low plasticity fines (LL = 25, PI = 10), 1% gravel to 3/8" maximum, firm to stiff, non-cemented, material becomes coarser with depth, G_s = 2.78

⑤ CLAYEY SAND (SC), orangish-brown, 5% moisture content, 83% very fine to coarse grained subangular to subrounded sand, 15% low plasticity fines (LL = 21, PI = 8), 2% gravel to 1/2" maximum, loose to firm, non-cemented

⑥ SANDY SILT (ML), dark brown, moist, est. 60-70% medium plasticity fines, est. 30-40% very fine grained sand, organic material (small roots) (F.C.)

⑦ SILT (ML), orangish-tan, dry, medium plasticity fines, stiff, non-cemented (F.C.)



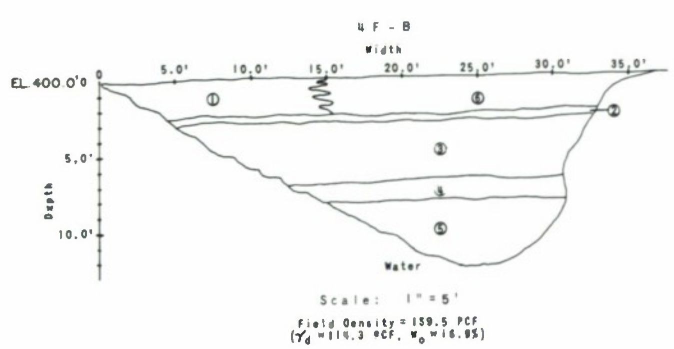
① SILTY SAND (SM), dark brown, moist to wet, 55% very fine to medium grained subangular to subrounded sand, 47% low to medium plasticity fines, abundant organic material (small roots, etc.), soft to firm, non-cemented

② SILTY SAND (SM), orangish-brown to reddish-brown with iron oxide staining, dry, 70% very fine to coarse grained sand, 30% low to medium plasticity fines, abundant organic material (roots, etc.), stiff to very stiff, moderately cemented, appears to be impervious

③ CLAYEY SAND (SC), brown to reddish-brown, 9% moisture content, 68% very fine to medium grained sand, 32% low plasticity fines (LL = 25, PI = 11), stiff to very stiff, slightly to moderately cemented, G_s = 2.79

④ SILTY SAND (SM), reddish-brown to orangish-brown, damp to moist, 79% very fine to coarse grained subangular to subrounded sand, 21% low to medium plasticity fines, dense to very dense, moderately cemented, some "books" of mica to 1/4" thick, sand content ranges to an est. 90% in some places

⑤ SILTY SAND (SM), gray to reddish-brown with iron oxide staining, moist to wet, 59% very fine to coarse grained sand, 44% fines, water percolating up through approximately 1/16" holes, contains zones of sandy clay and sandy silt which are too small to map, clays and silts are dark gray, carbonaceous, micaceous



① SANDY CLAY (CL), dark brown, wet, 52% fines (LL = 39, PI = 28), 47% very fine to medium grained sand, 1% gravel to 3/8", organic material (roots, grass, etc.), soft, non-cemented, water from recent rain standing on surface

② SANDY SILT (ML), reddish-brown to orangish-brown, dry, est. 50-60% non-plastic fines, est. 40-50% very fine to medium grained sand, very stiff to hard, moderately cemented, abundant soft white material as coating on fracture surfaces and solution cavities (F.C.)

③ SILTY SAND (SM), orangish-brown to grayish-brown, 13% moisture content, 55% very fine to medium grained sand, 45% low to medium plasticity fines, firm to stiff, non- to slightly cemented, unit varies in percent sand vs. fines, maximum size of material, consistency, color etc. throughout, moderately porous, G_s = 2.75

④ CLAYEY SAND (SC), brown with some iron oxide staining, 18% moisture content, 81% very fine to medium grained sand, 59% medium plasticity fines (LL = 29, PI = 10), soft to firm, non-cemented

⑤ SILTY SAND (SM), brick red with iron oxide staining, 11% moisture content, 62% very fine to coarse grained subangular to subrounded sand, 37% low to medium plasticity fines, 1% gravel to 3/8" maximum, very firm to dense, moderately cemented, small amount of water appeared at very bottom of trench just before backfilling

⑥ SILTY SAND (SM), dark reddish-brown, wet, 53% very fine to medium grained sand, 47% medium plasticity fines, abundant organic material (roots, grass, etc.), soft, non-cemented

NOTES:

1. Trenches 4F-4 thru 4F-8 were dug with an International 290A backhoe, equipped with a 24" bucket, on 19 November to 23 November 1982.
2. For location of trenches, see sheet No. B16 .
3. For additional notes and legend , see sheet No. B22 .
4. For additional logs of borings and trenches in the Big Dry Creek area, see sheet Nos. B9-B29.

GRAPHIC SCALE

1" = 5' 0 5' 10' 15' 20' 25'

REVISION	DATE	DESCRIPTION	BY	BY

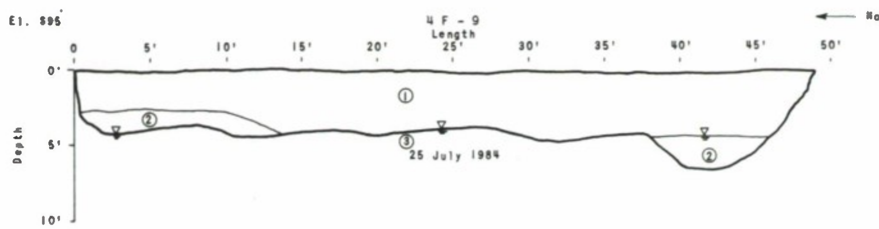
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DESIGNED: K. Swanson
DRAWN: K. Swanson
CHECKED: D. Anderson

REDBANK AND FANCHER CREEKS, CALIFORNIA
BIG DRY CREEK

BIG DRY CREEK DAM
LOGS OF EXPLORATIONS
4F-4 thru 4F-8

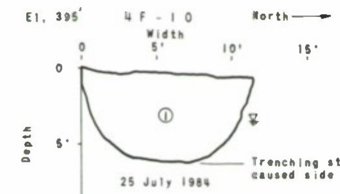
SUBMITTED: Chief, Soils Design Section
DATE APPROVED:
SCALE:
SPEC. No.
SHEET B 23 / 31
FILE No. SJ-11-20-11



① SANDY CLAY (CL), dark brown, 11% moisture content, 58% low plasticity fines (LL = 25, Pi = 11), 42% very fine to medium grained sand, hard and brittle top 0.5 to 1.0', firm below 1.0', non-cemented, highly organic

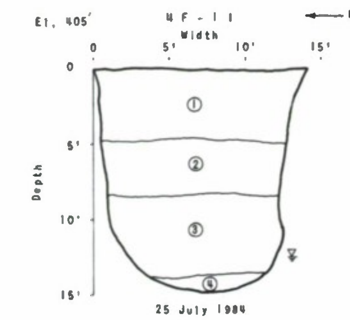
② SILTY SAND (SM), reddish-brown, 18% moisture content, 58% very fine to medium grained sand, 44% low plasticity fines, (LL = 20, PI = 3), firm to very dense, non to moderately cemented

③ SILTY SAND (SM), as above, moderately cemented, brittle, (F.C.)



Trenching stopped at 6.0' depth as in coming water caused side walls to cave.

① CLAYEY SAND (SC), dark brown, wet to saturated, est. 70-80% very fine to fine grained sand, est. 20-30% fines, abundent organics (grass, roots, etc.) loose to firm, non-cemented, (F.C.)

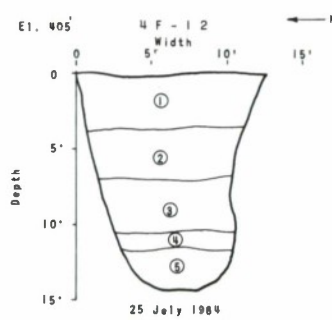


① SILTY SAND (SM), grey, dry, (Fill Material), (F.C)

② SILTY SAND (SM), tan, dry, Fill Material), (F.C.)

③ SILTY SAND (SM), dark brown, moist to saturated, est. 70-80% very fine to fine grained sand, est. 20-80% low to medium plasticity fines, loose to firm, non-cemented, (F.C.)

④ SANDY SILT (ML) reddish-brown, wet, est. 60-70% low to medium plasticity fines, est. 30-40% very fine to fine grained sand, dense to very dense, slightly to moderately cemented, (F.C.)



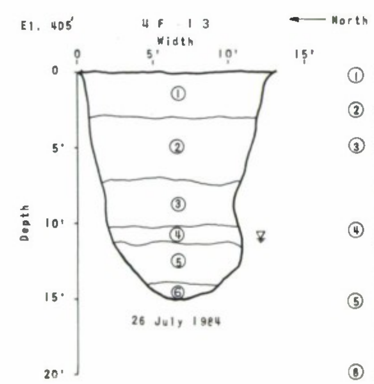
① SILTY SAND (SM), grey, dry, (Fill Materiel), (F.C.)

② SILTY SAND (SM), tan, dry, (Fill Materiel), (F.C.)

③ SILTY SAND (SM), dark brown, wet, est. 70-80% very fine to medium grained sand, est. 20-30% medium plasticity fines, firm, non-cemented, (F.C.)

④ SANDY CLAY (CL), dark brown, 18% moisture content, 52% low plasticity fines (LL = 27, PI = 15), 48% very fine to medium grained sand, loose to firm, non-cemented

⑤ SILTY SAND (SM), brown, saturated, est. 75-85% very fine to fine grained sand, est. 15-25% low to medium plasticity fines, loose, non-cemented (F.C.)



① SILTY SAND (SM), gray, dry, (Fill Material), (F.C.)

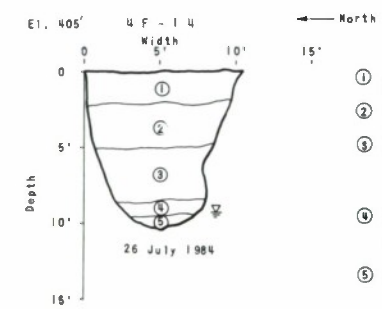
② SILTY SAND (SM), tan, dry, (Fill Material), (F.C.)

③ SILTY SAND (SM), reddish-brown, moist to wet, est. 60-70% very fine to fine grained sand, est. 30-40% low to medium plasticity fines, firm, non-cemented (Possibly Fill Material), (F.C.)

④ SANDY CLAY (CL), dark brown, 30% moisture content, 54% fines, 44% very fine to medium grained sand, 2% gravel to 1/2" maximum, loose to firm, non-cemented

⑤ CLAYEY SAND (SC), mottled brown and tan, wet, est. 60-70% very fine grained sand, est. 30-40% fines, loose to firm, non-cemented, (F.C.)

⑥ SANDY SILT (ML), tan to greenish-brown, moist, 68% medium plasticity fines, 32% very fine to medium plasticity fines, loose, non-cemented



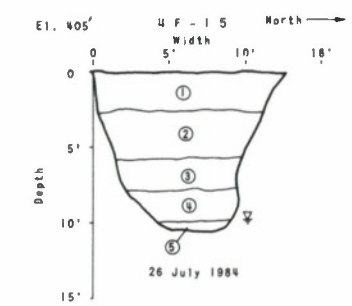
① SILTY SAND (SM), grey, dry, (Fill Materiel), (F.C.)

② SILTY SAND (SM), tan, dry, (Fill Material), (F.C.)

③ SILTY SAND (SM), brown, wet, est. 70-80% very fine to fine grained sand, est. 20-30% low plasticity fines, loose to firm, non-cemented, (F.C)

④ CLAYEY SAND (SC), dark brown, wet, est. 70-80% very fine to fine grained sand, est. 20-30% fines, loose to firm, non-cemented, (F.C.)

⑤ CLAYEY SAND (SC), brown, wet, est. 60% very fine grained sand, est. 40% fines, loose to firm, non-cemented, (F.C.)



① SILTY SAND (SM), gray, dry, (Fill Materiel)

② SILTY SAND (SM), tan, dry, (Fill Materiel)

③ SILTY SAND (SM), brown, wet, est. 70-80% very fine to fine grained sand, est. 20-30% low to medium plasticity fines, loose to firm, non-cemented

④ CLAYEY SAND (SC), dark brown, wet, est. 70-80% very fine to fine grained sand, est 20-30% fines loose to firm, non-cemented, (F.C.)

⑤ SANDY SILT (ML), reddish-brown with tan streaks, est 60-70% low plasticity fines, est. 30-40% very fine grained sand, stiff to hard, moderately cemented, brittle

NOTES

1. For locations fo trenches, see Sheet No. B15
2. For additional notes and legend, see Sheet No. B 22.
3. For additional logs of trenches in the Big Dry Creek area, see Sheet No. B 9 - B29.

GRAPHIC SCALE

1" = 5.0' 0 5' 10' 15' 20' 25'

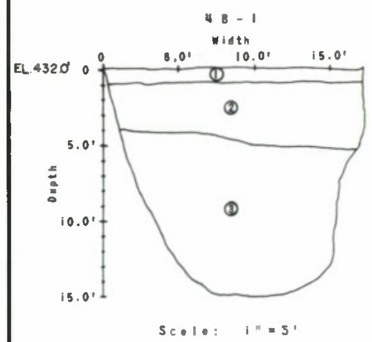
REVISION	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

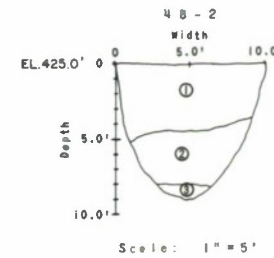
DESIGNED: K. Swanson
DRAWN: K. Wahl
CHECKED: D. Anderson

REDBANK AND FANCHER CREEKS, CALIFORNIA
BIG DRY CREEK
BIG DRY CREEK DAM
LOGS OF EXPLORATIONS
4F-9 thru 4F-15

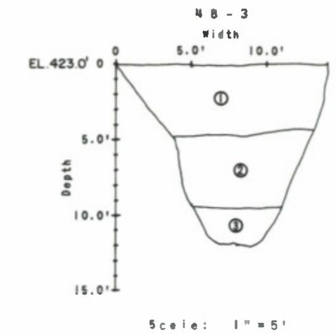
SUBMITTED: CHIEF, SOILS DESIGN SECTION
DATE APPROVED:
SCALE:
SPEC. No.
SHEET B24 32
FILE No. SJ-11-20-11



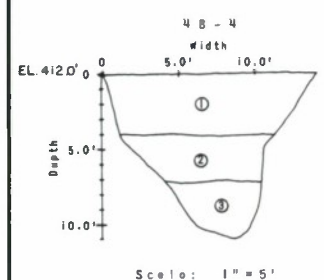
1. SAMPLE NOT TAKEN
2. SILTY SAND (SM), brown, 5% moisture content, 76% very fine to medium grained subangular to subrounded sand, 24% low plasticity fines (LL=15, PI=1), moderate amount of organic material (roots, etc.), very loose to loose, non-cemented
3. SILTY CLAYEY SAND (SC-SM), brown, 14% moisture content, 71% very fine to coarse grained subangular to subrounded with some coarse grained rounded sand, 29% low plasticity fines (LL=26, PI=7), some organic material (roots, etc.), stiff to very stiff, slightly to moderately cemented, a few solution cavities to 3/16" maximum, G_s=2.78



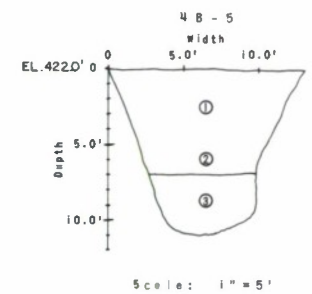
1. SAND (SP), light grey, dry to moist, 99% very fine to coarse grained angular to subrounded sand, 1% fines, very loose, non-cemented, abundant crossbedding with prominent zones of magnetite sand outlining the crossbedding
2. SAND (SP), light tan, 4% moisture content, 98% very fine to coarse grained angular to subrounded sand, 3% gravel to 5/8" maximum, 1% fines, very loose, non-cemented, moderate amount of crossbedding, G_s=2.73
3. SAND (SP), light tan, saturated, 94% very fine to coarse grained subangular to rounded sand, 5% rounded gravel to 1" maximum, 1% fines, very loose, non-cemented



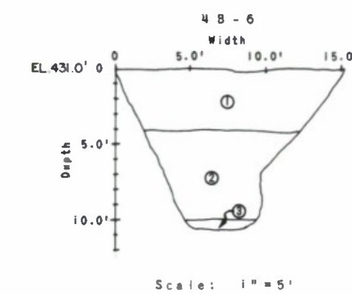
1. SANDY CLAY (CL), dark brown, damp, 63% medium plasticity fines, (LL=37, PI=22), 37% very fine to medium grained sand, abundant organic material (rootlets, etc.), stiff to very stiff, non-cemented, soft white coating on clay
2. SILTY CLAYEY SAND (SC-SM), brick red, 15% moisture content, 66% very fine to coarse grained sand, 34% low plasticity fines, (LL=29, PI=7), stiff to very stiff, non-cemented, micaceous
3. SILTY SAND (SM), dark brown, 22% moisture content, 66% very fine to coarse grained sand, 34% low to medium plasticity fines, firm to stiff, non-cemented, micaceous, G_s=2.75



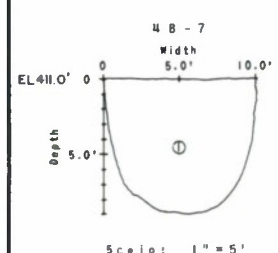
1. SILTY SAND (SM), dark brown, 4% moisture content, 77% very fine to medium grained sand, 23% non- to low plasticity fines, small amount of organic material (roots, etc.), firm to very firm, non-cemented
2. CLAYEY SAND (SC), orangish-brown, 6% moisture content, 74% very fine to coarse grained angular to subangular sand, 25% low plasticity fines (LL=27, PI=12), 1% gravel to 3/8" maximum, dense to very dense, moderately cemented, white material on surfaces of broken chunks
3. SILTY SAND (SM), orangish-brown, damp, 61% very fine to coarse grained subangular to subrounded sand, 18% non- to low plasticity fines, 5% fine gravel, firm to very firm, non- to slightly cemented, G_s=2.78



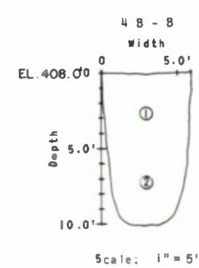
1. SANDY SILT - SANDY CLAY (ML-CL), brown, 8% moisture content, 81% low plasticity fines (LL=18, PI=7), 49% very fine to medium grained subangular sand, some organic material (rootlets, etc.), soft to firm, non-cemented, depth to contact between material 1 and material 2 is unknown
2. SILTY SAND (SM), brown, 11% moisture content, 68% very fine to medium grained sand, 31% low plasticity fines, 1% fine gravel, some organic material (rootlets, etc.), soft to firm, non-cemented
3. SILTY SAND (SM), greyish-brown to brown, 9% moisture content, 71% very fine to medium grained angular to subrounded sand, 27% low plasticity fines, 2% gravel to 1/2" maximum, firm, non-cemented



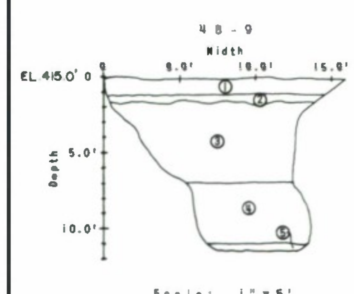
1. SILTY CLAYEY SAND (SM-SC), brown, 3% moisture content, 81% very fine to medium grained angular to subangular sand, 19% low plasticity fines (LL=18, PI=4), loose, non-cemented, G_s=2.75
2. SILTY SAND (SM), dark brown to orangish-brown, 8% moisture content, 79% very fine to coarse grained subangular to subrounded sand, 15% non- to low plasticity fines, 6% gravel to 1-1/2" maximum, very firm to dense, non- to slightly cemented
3. CLAYEY SAND (SC), greyish-brown to brown, 13% moisture content, 64% very fine to medium grained sand, 36% low plasticity fines, (LL=26, PI=7), firm to stiff, non-cemented, micaceous



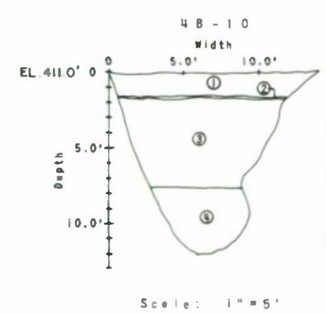
1. GRAVELLY SAND (SP), light grey to greyish-brown, 4% moisture content, 81% very fine to coarse grained subangular to rounded sand, 16% gravel to 1-1/2" maximum, 1% fines, very loose, abundant crossbedding



1. SAND (SP), grey to brownish-grey, 4% moisture content, 96% very fine to coarse grained subangular to rounded sand, 4% rounded gravel to 1/2" maximum, abundant crossbedding, depth to contact between material 1 and material 2 is unknown
2. GRAVELLY SAND (SW), grey to brownish-grey, moist, 81% very fine to coarse grained subangular to rounded sand, 18% rounded gravel to 3/4" maximum, 1% fines, very loose, abundant crossbedding



1. SILTY SAND (SM), brown to dark brown, 7% moisture content, 88% very fine to coarse grained angular to subrounded sand, 31% low plasticity fines, 1% gravel to 3/8" maximum, loose, non-cemented
2. SILTY SAND (SM), as above except dry (F.C.)
3. CLAYEY SAND (SC), brown, 3% moisture content, 73% very fine to medium grained angular to subangular sand, 27% non- to low plasticity fines, firm to dense, slightly cemented, material breaks up along existing fractures that are coated with white soft to moderately soft material, G_s=2.76, LL=20, PI=8
4. SILTY SAND (SM), orangish-brown, 4% moisture content, 85% very fine to coarse grained subangular to rounded sand, 13% low plasticity fines, 2% gravel to 3/8" maximum, loose to firm, non-cemented
5. SILTY CLAYEY SAND (SC-SM), reddish-brown, 9% moisture content, 68% very fine to medium grained angular sand, 31% low plasticity fines (LL=22, PI=7), 1% gravel to 3/8" maximum, stiff to very stiff, slightly to moderately cemented



1. CLAYEY SAND (SC), dark brown, 14% moisture content, 58% very fine to medium grained sand, 41% low plasticity fines (LL=22, PI=10), 1% gravel to 3/8" maximum, abundant organic material (roots, grass, etc.), very soft to soft, non-cemented
2. SILT (ML), brick red, moist, medium plasticity fines, stiff to very stiff, moderately cemented, streaks of white material throughout, impervious (F.C.)
3. SILTY SAND (SM), orangish-brown, 12% moisture content, 77% very fine to coarse grained angular to subrounded sand, 23% low plasticity fines, firm to stiff, non- to slightly cemented (grain size, texture and cementation very throughout), G_s=2.74
4. SANDY CLAY (CL), mottled tan and light brown, 22% moisture content, 60% medium plasticity fines (LL=47, PI=29), 39% very fine to coarse grained sand, 1% gravel to 3/8" maximum, loose to slightly firm, non-cemented

LEGEND:

LL	Liquid Limit.
PI	Plasticity index (Liquid Limit Minus Plastic Limit).
(F.C.)	Visual Field Classification.
*	Laboratory Visual Classification.
▽	Water Level.
G_s	Specific Gravity (Minus No. 4).
γ_d	Dry Unit Weight.

NOTES:

1. Trenches 4B-1 through 4B-10 were dug with an International 260A backhoe equipped with a 24" bucket during 8-19 November 1962.
2. For Location of Trenches, see sheet No. B16.
3. For additional Logs of Borings and Trenches, see sheet Nos. B 3-B29.
4. Classifications are in accordance with the Unified Soils Classification System.
5. The terms "silt" and "clay" are used respectively to distinguish materials exhibiting lower plasticity from those with higher plasticity. The minus No. 200 sieve material is silt if the liquid limit and plasticity index plot below the "A" line on the plasticity chart (ASTM D-2487) and is clay if the liquid limit and plasticity index plot above the "A" line on the chart.
6. Borderline Classification: Soils possessing characteristics of two groups are designated by combinations of group symbols. For example GW-GC, a well-graded gravel-sand mixture with a clay binder.
7. Groundwater was encountered during trenching.

GRAPHIC SCALE
1" = 5' 0 5' 10' 15' 20' 25'

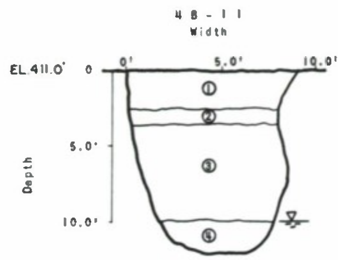
ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING

REVISION	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

REDBANK AND FANCHER CREEKS, CALIFORNIA
BIG DRY CREEK
BIG DRY CREEK DAM
LOGS OF EXPLORATIONS
4B-1 thru 4B-10

DESIGNED: K Swanson
DRAWN: K Wahl
CHECKED: D Anderson
SUBMITTED: CHIEF, SOILS DESIGN SECTION
DATE APPROVED
SCALE:
SHEET B 25 / 33
SPEC. No.
FILE No. SJ-11-20-11

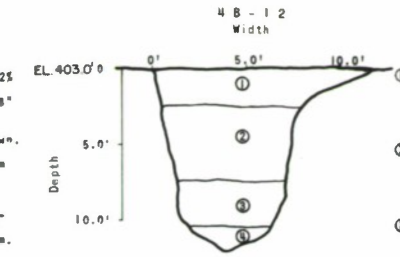


① SILTY SAND (SM), medium brown, dry, 52% very fine to medium grained sand, 47% low plasticity fines, 1% gravel to 3/8" maximum, loose to firm, non-cemented

② SILTY SAND (SM), medium yellowish-brown, dry, est. 60-70% fine grained sand, est. 30-40% low plasticity fines, firm to dense, moderately cemented (F.C.)

③ CLAYEY SAND (SC), medium brown, 13% moisture content, 65% very fine to medium grained sand, 32% low plasticity fines, (LL = 25, PI = 11), loose to firm, non-cemented

④ *SILTY SAND (SM), dark brown, wet, est. 60% fine grained sand, est. 40% low plasticity fines, non-cemented, micaceous

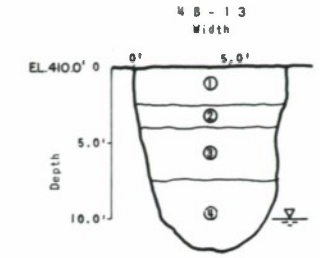


① SANDY SILT (ML), dusky yellowish-brown, 12% moisture content, 66% medium to high plasticity fines, 32% very fine to medium grained sand, firm to stiff, non-cemented

② SANDY CLAY (CL), medium brown, damp, 53% low plasticity fines (LL = 30, PI = 15), 47% very fine to medium grained sand, soft, non-cemented, G_s = 2.75

③ SILTY SAND (SM), dark yellowish-brown, damp, est. 70% very fine to fine grained sand, est. 30% medium to high plasticity fines, firm, non-cemented (F.C.)

④ *SANDY SILT (ML), dark brown, wet, est. 55% low plasticity fines, est. 45% fine grained sand, loose to firm, non-cemented, micaceous

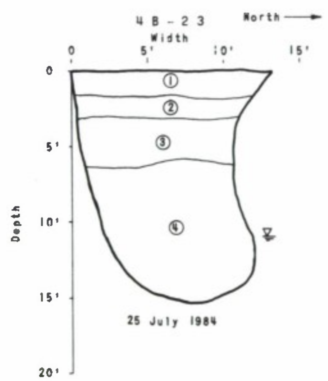


① SANDY SILT, medium brown, est. 55-60% low plasticity fines est. 40-45%, very fine to fine grained sand, soft to firm, non-cemented (F.C.)

② SILTY SAND, medium yellowish-brown, est. 60-70% fine grained sand, est. 30-40% low plasticity fines, firm to dense, moderately cemented (F.C.)

③ SILTY SAND, medium brown, damp, est. 60-90% fine to medium grained sand, est. 10-20% low plasticity fines, loose, non-cemented (F.C.)

④ SILTY CLAYEY SAND (SM-SC), medium yellowish-brown, 32% moisture content, 55% very fine to medium grained sand, 45% low plasticity fines (LL = 26, PI = 5), loose, non-cemented

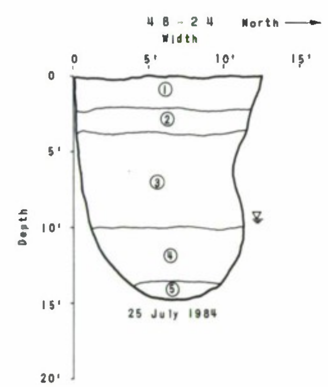


① SANDY SILT (ML), light brown to tan, dry, est. 70-80% fines, est. 20-30% very fine to fine grained sand, dense, non-cemented (F.C.)

② SANDY SILT (ML), dark reddish-brown with abundant stringers of white material, dry to damp, est. 20-30% very fine to medium grained sand, very dense, moderately cemented (hard pan), (F.C.)

③ CLAYEY SAND (SC), brown, damp to moist, 64% very fine to medium grained sand, 36% low plasticity fines (LL = 25, PI = 9), firm, non-cemented

④ CLAYEY SAND (SM - SC), reddish-brown, moist to saturated, 55% very fine to medium grained sand, 44% low plasticity fines (LL = 22, PI = 6), firm to very firm, non-cemented



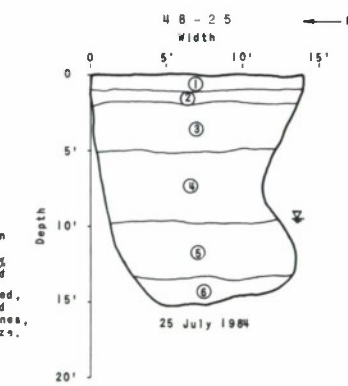
① SANDY SILT (ML), light brown to tan, dry, est. 50-70% low to medium plasticity fines, est. 30-40% very fine to fine grained sand, stiff, non-cemented, (F.C.)

② SANDY SILT (ML), dark reddish-brown with abundant stringers of white material, est. 70-80% low plasticity fines, est. 20-30% very fine to medium grained sand, very stiff, moderately cemented, (F.C.)

③ SILTY SAND (SM), brown to reddish-brown damp to wet, 74% very fine to medium grained sand, 25% non-plastic fines, 1% gravel to 1/2" size, firm, non-cemented

④ SILTY SAND (SM), reddish-brown, saturated, est. 80-90% very fine to medium grained sand, est. 10-20% medium plasticity fines, scattered subangular gravel to 3/4" size, non-cemented, (F.C.)

⑤ SILTY SAND (SM), reddish-brown with stringers of light tan material, dense to very dense, slightly to moderately cemented, brittle, (F.C.)



① SANDY SILT (ML), light brown to tan, dry, est. 50-70% low plasticity fines, est. 30-40% very fine to fine grained sand, stiff, non-cemented, (F.C.)

② SANDY SILT (ML), dark-reddish-brown with stringers of white material, damp, est. 70-80% low plasticity fines, est 20-30% very fine to fine grained sand, very stiff, moderately cemented, brittle, (F.C.)

③ CLAYEY SAND (SM-SC), brown, damp, 51% very fine to medium grained sand, 39% low plasticity fines (LL = 24, PI = 6), firm, non-cemented

④ SANDY CLAYEY SILT (ML), reddish-brown, moist, 55% medium plasticity fines, 41% very fine to fine grained sand, 4% gravel to 3/4" size, firm to dense, non to slightly cemented

⑤ SANDY SILTY CLAY, greenish-brown, wet, 51% medium plasticity fines, (LL = 38, PI = 14), 49% very fine to medium grained sand, firm, non-cemented, micaceous

LEGEND:

LL	Liquid Limit.
PI	Plasticity Index (Liquid Limit Minus Plastic Limit).
(F.C.)	Visual Field Classification.
∇	Water Level.
S_s	Specific Gravity. (Minus No. 4)
*	Laboratory Visual Classification.

NOTES:

1. Trenches 4B-11 through 4B-13 were dug with a backhoe on 11 August 1983.
2. For Location of Trenches, see sheet No. B16.
3. For additional Logs of Borings and Trenches in the Big Dry Creek area, see sheet Nos. B 9 - B 29.
4. For additional notes and legend, see sheet No. B 25.
5. Groundwater was encountered during trenching.

GRAPHIC SCALE

1" = 5' 0 1' 2' 3' 4' 5' 10' 15' 20' 25'

REVISION	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DESIGNED: K. SWANSON
DRAWN: K. WAHL/J. HAYES
CHECKED: D. ANDERSON
SUBMITTED: CHIEF, SOILS DESIGN SECTION

REDBANK AND FANCHER CREEKS, CALIFORNIA
BIG DRY CREEK

BIG DRY CREEK DAM
LOGS OF EXPLORATIONS
4B-11 thru 4B-13 and 4B-23 thru 4B-25

DATE APPROVED:
SCALE:
SHEET B 26 / 34
FILE No. SJ-11-20-11
SPEC. No.

7 F - 1

EL. 435.8'

Depth	Group	GR	SA	FI	LL	PI	MC	Description
0 – 0.5'	(F)	-	-	-	-	-	-	GRAVEL, loose (road bed)
0.5' – 2.5'	SM	0	68	32	-	-	-	SILTY SAND, very fine to medium grained sand (F.C.)
2.5' – 5.0'	SC-SM	0	61	39	21	6	12	SILTY CLAYEY SAND, reddish-brown, very fine to fine grained sand
								*CLAYEY GRAVELLY SAND, dark grey-brown, damp, est. 60-65% fine to medium grained sand, est. 10-15% hard subangular to subrounded gravel to 5/8" maximum, est. 5% low plasticity fines, loose density
5.0' – 5.6'	SP-SC							
5.6' – 7.5'	SC	-	-	-	-	-	-	*CLAYEY SAND, dark brown, damp, 60% medium grained sand, 40% medium plasticity fines
7.5' – 10.0'	CL	0	39	61	29	8	16	SANDY CLAY, reddish-brown, very fine to medium grained sand, G_s = 2.76
10.0' – 12.2'	SC-SM	0	57	43	20	6	7	SILTY CLAYEY SAND, reddish-brown with iron oxide staining, very fine to medium grained sand, low plasticity fines, γ_d = 129.2 PCF
12.2' – 13.6'		0	62	36	-	NP	6	SILTY SAND, reddish-brown, very fine to medium grained sand
13.6' – 15.4'	SM	-	-	-	-	-	-	*SILTY SAND, dark brown, damp, est. 65-90% fine to medium grained sand, est. 10-15% low plasticity fines, low density, micaceous
15.4' – 17.9'		0	66	34	24	11	9	CLAYEY SAND, reddish-brown, very fine to medium grained sand, G_s = 2.74
17.9' – 19.6'	SC	-	-	-	-	-	-	*CLAYEY SAND, reddish-brown, damp, est. 55-65% medium grained sand, est. 35-45% medium plasticity fines, high density, micaceous
19.6' – 21.5'		0	67	33	16	1	11	SILTY SAND, reddish-brown with iron oxide staining, very fine to medium grained sand
21.5' – 24.0'	SM	-	-	-	-	-	-	*SILTY SAND, dark reddish-brown, damp, est. 60-65% fine to medium grained sand, est. 15-20% low to medium plasticity fines, medium density, micaceous
24.0' – 26.7'	SC-SM	0	67	33	21	7	14	SILTY CLAYEY SAND, reddish-brown, very fine to medium grained sand, γ_d = 115.4 PCF
26.7' – 29.5'		-	-	-	-	-	-	*SILTY SAND, dark reddish-brown, damp, est. 60-65% fine to medium grained sand, est. 15-20% low to medium plasticity fines, medium density, micaceous
29.5' – 32.5'	SM	0	54	46	12	1	10	SILTY SAND, dark reddish-brown, very fine to medium grained sand
32.5' – 35.3'	SC-SM	-	-	-	-	-	-	*SILTY CLAYEY SAND, reddish-brown, damp, est. 70-75% medium grained sand, est. 25-30% medium plasticity fines, medium density, micaceous
35.3' – 36.1'		0	56	42	16	5	14	SILTY CLAYEY SAND, dark brown, very fine to fine grained sand, micaceous
36.1' – 36.4'	(SC)	-	-	-	-	-	-	CLAYEY SAND, light brown to reddish-brown, moist, very fine to fine grained sand, low plasticity, micaceous (F.C.)
36.4' – 40.2'		-	-	-	-	-	-	*CLAYEY SILTY SAND, brown, damp, est. 75-80% fine to medium grained sand, est. 20-25% medium plasticity fines, low density, micaceous, γ_d = 123.4 PCF At 39.2' as above except reddish-brown, medium density
40.2' – 43.0'	SC-SM	0	63	37	26	6	15	SILTY CLAYEY SAND, reddish-brown with iron oxide staining, very fine to medium grained sand, micaceous, G_s = 2.76
43.0' – 45.9'		-	-	-	-	-	-	*SILTY CLAYEY SAND, reddish-brown, damp, est. 75-80% fine to medium grained sand, est. 20-25% low to medium plasticity fines, micaceous
45.9' – 46.7'	SM	0	72	26	-	NP	20	SILTY SAND, reddish-brown, very fine to medium grained sand
46.7' – 51.5'	SM-SC	-	-	-	-	-	-	*SILTY CLAYEY SAND, reddish-brown, damp, est. 70-75% fine to medium grained sand, est. 25-30% low to medium plasticity fines, medium density, micaceous, carbonaceous
51.5' – 54.3'	ML	0	42	56	23	5	21	SANDY SILT, light to dark brown, very fine to fine grained sand, highly micaceous, carbonaceous, γ_d = 106.7 PCF
54.3' – 57.1'		-	-	-	-	-	-	SILTY CLAYEY SAND, reddish-brown with mottled grey-brown, damp, est. 60% fine to medium grained sand, est. 40% medium plasticity fines, high density, micaceous
57.1' – 59.9'		0	57	43	25	6	20	SILTY CLAYEY SAND, light reddish-brown with light grey sandy seams, very fine to fine grained sand, micaceous
59.9' – 62.7'	SC-SM	-	-	-	-	-	-	*SILTY CLAYEY SAND, reddish-brown with mottled grey-brown, damp, est. 65-75% fine to medium grained sand, est. 25-35% medium plasticity fines
62.7' – 65.6'		0	54	46	27	5	23	SILTY CLAYEY SAND, reddish-brown, very fine to medium grained sand
65.6' – 66.4'		-	-	-	-	-	-	*CLAYEY SAND, reddish-brown with mottled grey-brown, damp, est. 55-60% fine to medium grained sand, est. 40-45% medium plasticity fines, micaceous
66.4' – 71.2'	SC	0	56	44	29	9	20	CLAYEY SAND, dark reddish-brown, very fine to medium grained sand
71.2' – 72.8'		-	-	-	-	-	-	*CLAYEY SAND, reddish-brown with mottled grey-brown, est. 55-60% fine to medium grained sand, est. 40-45% medium plasticity fines, micaceous

EXISTING EMBANKMENT (0 – 32.5')

FOUNDATION (32.5' – 72.8')

7 F - 2

EL. 435.5'

Depth	Group	GR	SA	FI	LL	PI	MC	Description
0 – 0.5'	(F)	-	-	-	-	-	-	GRAVEL, loose (road bed) (F.C.)
0.5' – 2.5'	SC-SM	0	51	49	21	4	17	SILTY CLAYEY SAND, reddish-brown, very fine to fine grained sand
2.5' – 4.7'		-	-	-	-	-	-	*CLAYEY SAND, reddish-brown, damp, est. 60-65% fine to medium grained sand, est. 35-40% medium plasticity fines, high density, micaceous
4.7' – 7.3'		0	51	49	27	8	14	CLAYEY SAND, reddish-brown, very fine to fine grained sand, γ_d = 118.6 PCF
7.3' – 9.9'		-	-	-	-	-	-	*CLAYEY SAND, reddish-brown, damp, est. 60-65% fine to medium grained sand, est. 35-40% medium plasticity fines, high density, micaceous
9.9' – 12.6'	SC	0	56	44	23	8	15	CLAYEY SAND, reddish-brown, very fine to medium grained sand
12.6' – 15.3'		-	-	-	-	-	-	*CLAYEY SAND, reddish-brown, damp, est. 65-75% fine to medium grained sand, est. 25-35% medium plasticity fines, high density, micaceous
15.3' – 18.0'		0	53	47	27	11	6	CLAYEY SAND, reddish-brown, very fine to medium grained sand, G_s = 2.74
18.0' – 20.8'		-	-	-	-	-	-	*CLAYEY SAND, reddish-brown, damp, est. 55-65% fine to medium grained sand, est. 35-45% medium plasticity fines, high density, micaceous
20.8' – 23.6'	SM-SC	0	75	25	19	5	10	CLAYEY SILTY SAND, light reddish-brown, very fine to coarse grained sand, some pieces of cemented materials, micaceous
23.6' – 24.6'		-	-	-	-	-	-	*SILTY CLAYEY SAND, dark brown, damp, est. 55-60% fine to medium grained sand, est. 40-45% medium plasticity fines, medium density, micaceous
24.6' – 25.0'	(CL)	-	-	-	-	-	-	*SANDY CLAY, dark gray-brown, est. 55-60% medium plasticity fines, est. 40-45% fine to medium grained sand, organics, medium density
25.0' – 26.3'	SM-SC	-	-	-	-	-	-	*SILTY CLAYEY SAND, reddish-brown, damp, est. 60-70% medium grained sand, est. 30-40% medium plasticity fines, medium density, micaceous
26.3' – 29.1'	SM	0	59	41	14	2	12	SILTY SAND, dark brown, very fine to coarse grained sand, γ_d = 123.7 PCF
29.1' – 30.2'	SC	-	-	-	-	-	-	*CLAYEY SAND, reddish-brown with a gray-black sandy clay layer 2-3" thick
30.2' – 30.8'	CH	-	-	-	-	-	-	*SANDY CLAY, black, damp, est. 55-60% high plasticity fines, est. 40-45% fine to medium grained sand, low density
30.8' – 31.9'	SC	-	-	-	-	-	-	*CLAYEY SAND, reddish-brown, damp, est. 60-65% fine to medium grained sand, est. 35-40% medium plasticity fines, low density, micaceous
31.9' – 35.1'	CL-ML	0	40	60	25	4	12	SANDY CLAY - SANDY SILT, dark reddish-brown, very fine to medium grained sand, hard, well cemented
35.1' – 35.8'	SC	-	-	-	-	-	-	*CLAYEY SAND, reddish-brown with mottled gray-brown, damp, est. 55-60% fine to medium grained sand, est. 40-45% medium plasticity fines, high density, micaceous
35.8' – 37.8'	SM-SC	-	-	-	-	-	-	*SILTY CLAYEY SAND, reddish-brown, damp, est. 55-60% fine grained sand, est. 40-45% low to medium plasticity fines, low density, micaceous
37.8' – 40.6'	SC	0	72	28	28	10	-	CLAYEY SAND, reddish-brown, very fine to fine grained sand
40.6' – 42.2'		2	62	36	25	11	-	CLAYEY SAND, reddish-brown, very fine grained sand, gravel to 3/8" maximum, micaceous, G_s = 2.75
42.2' – 44.9'	SM	8	66	26	-	-	13	SILTY SAND, brown to reddish-brown, very fine to coarse grained sand, medium plasticity fines, gravel to 1/2" maximum, firm density, non-cemented, some carbonaceous material, stringers of low plasticity silty sand, G_s = 2.75
44.9' – 46.1'	(SM)	-	-	-	-	-	-	SILTY SAND, reddish-brown, wet, est. 60-70% very fine to coarse grained angular to subrounded sand, est. 30-40% low plasticity fines, scattered gravel to 2" maximum, firm density, non-cemented, contains fragments of non to slightly weathered granitic material
46.1' – 48.5'	SC	-	-	-	-	-	-	CLAYEY SAND, brown, damp, est. 70-75% fine to coarse grained sand, 25-30% medium plasticity fines, traces of hard subrounded gravel to 1/2" maximum, micaceous
48.5' – 49.7'	(SM)	-	-	-	-	-	-	SILTY SAND, brick red, wet, est. 60-70% fine to medium grained angular to subrounded sand, est. 30-40% non to low plasticity fines, scattered fine rounded decomposed granitic gravels (F.C.)
49.7' – 52.2'	ML	0	33	67	32	7	18	SANDY SILT, orangish-brown, very fine to medium grained sand, firm to stiff, micaceous, black carbonaceous stringers, γ_d = 110.5 PCF
52.2' – 53.8'	CL	-	-	-	-	-	-	*SANDY CLAY, reddish-brown, damp, est. 70-75% medium plasticity fines, est. 25-30% fine to medium grained sand, hard
53.8' – 54.8'	SC	-	-	-	-	-	-	*CLAYEY SAND, reddish-brown, damp, est. 80-85% fine to medium grained sand, est. 15-20% medium plasticity fines, micaceous
54.8' – 56.6'		0	45	55	36	9	18	SANDY CLAY, brown, medium plasticity fines, very fine to medium grained sand, very stiff, non-cemented, areas of greenish-gray sandy silt to 2" maximum found in bottom of sampler, G_s = 2.76
56.6' – 59.3'	CL	-	-	-	-	-	-	*SANDY CLAY, reddish-brown with mottled gray-brown, damp, est. 60-65% medium plasticity fines, est. 35-40% fine to medium grained sand, stiff, micaceous
59.3' – 71.8'	(F)	-	-	-	-	-	-	Sample Lost (F.C.)
71.8' – 72.0'	(ML)	-	-	-	-	-	-	*SANDY SILT, brown, moist, est. 55-60% medium plasticity fines, est. 40-45% fine grained sand, micaceous
72.0' – 72.9'		-	-	-	-	-	-	SANDY SILT, brown, damp, est. 60-70% medium to high plasticity fines, est. 30-40% very fine to fine grained sand (F.C.)
72.9' – 75.5'	(ML)	-	-	-	-	-	-	SANDY SILT, as above except with a stringer of moderately soft material running through the bottom of the sample (F.C.)

EXISTING EMBANKMENT (0 – 31.9')

FOUNDATION (31.9' – 75.5')

Vertical Scale: 1" = 4'

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			GROUP SYMBOLS	TYPICAL NAMES
COARSE GRAINED SOILS 50% or more retained on the No. 200 sieve.	GRAVELS More than half of coarse fraction retained on the No. 4 sieve.	Clean Gravels	GW	Well-graded gravels, gravel-sand mixtures, little or no fines.
			GP	Poorly-graded gravels, gravel-sand mixtures, little or no fines.
		Gravels with fines	GM	Silty gravels, gravel-sand mixtures.
			GC	Clayey gravels, gravel-sand-clay mixtures.
	SANDS More than half of coarse fraction passing the No. 4 sieve.	Clean sands	SW	Well-graded sands, gravelly sands, little or no fines.
			SP	Poorly-graded sands, gravelly sands, little or no fines.
		Sands with fines	SM	Silty sands, sand-silt mixtures.
			SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS More than 50% passing the No. 200 sieve.	SILTS AND CLAYS	Liquid Limit below 50%	ML	Inorganic silts and very fine sands, rock flour, silty fine sands or silts. Plasticity below "A" line.
			CL	Inorganic clays, gravelly clays, sandy clays, lean clays. Plasticity above "A" line.
			OL	Organic silts and organic clays. Plasticity below "A" line.
		Liquid Limit 50% and above	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts. Plasticity below "A" line.
			CH	Inorganic fat clays. Plasticity above "A" line.
			OH	Organic clays or organic silts. Plasticity below "A" line.
Highly organic soils			Pt	Peat, organic content greater than 80%.

LEGEND:

- GR — Gravel, percent by weight passing 3-inch sieve and retained on the No. 4 sieve.
- SA — Sands, percent by weight passing the No. 4 sieve and retained on the No. 200 sieve.
- FI — Fines, percent by weight passing the No. 200 sieve.
- LL — Liquid Limit.
- PI — Plasticity Index (Liquid Limit Minus Plastic Limit).
- MC — Field Moisture Content in Percent of Dry Weight.
- ▽ — Groundwater Level.
- * — Laboratory Visual Classification.
- ( ) — Field Unified Soil Classification (For Logs of Borings only).
- (F) — No Unified Soil Classification Available.
- γ_d — Dry Unit Weight.
- G_s — Specific Gravity (Minus No. 4)

NOTES:

1. Classifications are in accordance with the Unified Soils Classification System (ASTM D-2487).
2. All sieve sizes on the chart are U.S. Standard.
3. The terms "silt" and "clay" are used respectively to distinguish materials exhibiting lower plasticity from those with higher plasticity. The minus No. 200 sieve material is silt if the liquid limit and plasticity index plot below the "A" line on the plasticity chart (ASTM D-2487) and is clay if the liquid limit and plasticity index plot above the "A" line on the chart.
4. Borderline Classification: Soils possessing characteristics of two groups are designated by combinations of group symbols. For example GW-GC, a well-graded gravel-sand mixture with a clay binder.
5. For additional Logs of Borings and Trenches, see sheets P 9 - B29.
6. For Location of Explorations, see sheet B6.
7. Borings 7F-1 through 7F-6 were drilled with a Mobile B-53 drill rig equipped with a 6-inch pitcher sampler from 17 November through 6 December 1962. Borings 7F-7 and 7F-8 were drilled with a Failing drill rig equipped with a 6-inch pitcher sampler during 23-25 August 1963.
8. Depth to groundwater is shown if measured.

GRAPHIC SCALE

1" = 4'   0 1' 2' 3' 4'   8'   12'   16'   20'

REVISION	DATE	DESCRIPTION	BY
△			
△			

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DESIGNED: K. Swanson
DRAWN: K Wohl / H Wilson
CHECKED: D. Anderson
SUBMITTED: [signature] CHIEF, SOILS DESIGN SECTION
DATE APPROVED: 4/24/86

REDBANK AND FANCHER CREEKS, CALIFORNIA
BIG DRY CREEK
BIG DRY CREEK DAM
LOGS OF EXPLORATIONS
7F-1 and 7F-2

SHEET B27 / 35 — FILE No. SJ-11-20-11

ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING

FUNCTIONAL ANALYSIS - VE PAYS

7 F - 3

EL. 435.5'

Depth		GR	SA	FI	LL	PI	MC	Description
0 – 55.3'	(F)							Drilled to 55.3' depth with a Tri-Cone drill bit, material not sampled
55.3' – 57.6'	SC-SM	-	-	-	-	-	-	SILTY CLAYEY SAND, reddish-brown with mottled grey-brown, damp, est. 85 - 90% medium to coarse grained sand, est. 10 - 15% low to medium plasticity fines, trace of hard subrounded gravel, low density, micaceous
57.6' – 58.3'	(F)	-	-	-	-	-	-	SAMPLE LOST (F.C.)
58.3' – 61.1'	MH	0	12	86	-	-	-	SILT, reddish-brown, damp, medium to high plasticity fines, very fine to medium grained sand, stiff, non-cemented, carbonaceous
61.1' – 61.7'	(F)	-	-	-	-	-	-	SAMPLE LOST
61.7' – 62.6'	CL	-	-	-	-	-	-	SANDY CLAY, reddish-brown with mottled grey-brown, damp, est. 70-75% medium plasticity fines, est. 25-30% fine to medium grained sand, hard, micaceous
62.6' – 63.5'	SC	-	-	-	-	-	-	CLAYEY SAND, reddish-brown, damp, est. 65-70% fine to medium grained sand, est. 30-35% medium plasticity fines, low density, micaceous
63.5' – 64.0'	(F)	-	-	-	-	-	-	SAMPLE LOST (F.C.)
64.0' – 66.3'	MH	0	38	62	-	-	-	SANDY SILT, brown, moist, high plasticity fines, very fine to medium grained sand, non-cemented, abundant carbonaceous material throughout
66.3' – 68.7'	MH	0	46	51	-	-	23	SANDY SILT, greenish-brown, medium to high plasticity fines, very fine to medium grained sand, stiff, non-cemented, some carbonaceous material
68.7' – 71.0'	(MH)	-	-	-	-	-	-	SILT, as above, except brown (F.C.)
71.0' – 73.2'	SM	0	50	50	-	-	20	SILTY SAND, brown, very fine to medium grained sand, medium plasticity fines, loose to firm, non-cemented, micaceous, carbonaceous

FOUNDATION (55.3' – 73.2')

7 F - 4

EL. 435.5'

Depth		GR	SA	FI	LL	PI	MC	Description
0 – 2.3'	(SM)	-	-	-	-	-	-	GRAVEL on surface SILTY SAND, brown, damp, est. 60-70% very fine to fine grained sand, est. 30-40% low to medium plasticity fines, loose to firm, non-cemented (F.C.)
2.3' – 4.3'	SC	0	65	35	-	-	-	CLAYEY SAND, brown, very fine to medium grained sand, loose to firm, non-cemented, micaceous
4.3' – 6.5'	SC	0	64	36	20	9	12	CLAYEY SAND, as above, γ_d = 116.4 PCF
6.5' – 8.8'	SC	-	-	-	-	-	-	CLAYEY SAND, dark brown, damp, est. 60-70% fine to medium grained sand, est. 30-40% medium plasticity fines, 1 to 2" diameter clay balls, medium density, micaceous
8.8' – 10.4'	SC	0	56	42	-	-	14	CLAYEY SAND, as above
10.4' – 12.6'	SC	-	-	-	-	-	-	CLAYEY SAND, reddish-brown, damp, est. 60-70% fine to medium grained sand, est. 30-40% medium plasticity fines, micaceous
12.6' – 15.2'	SC-SM	1	54	45	22	7	13	SILTY CLAYEY SAND, reddish-brown, very fine to medium, subangular to subrounded grained sand, firm, non-cemented, micaceous, some granitic material, G_s = 2.76
15.2' – 17.5'	SC-SM	-	-	-	-	-	-	SILTY CLAYEY SAND, dark brown, damp, est. 60-65% fine to medium grained sand, est. 15-20% low to medium plasticity fines, trace of hard subrounded gravel to 3/8" maximum, low density, micaceous
17.5' – 19.7'	SM	0	64	36	-	-	-	SILTY SAND, reddish-brown, damp to moist, very fine to medium, subangular to subrounded grained sand, medium plasticity fines, firm, non-cemented, micaceous
19.7' – 21.2'	SM	0	79	21	15	1	6	SILTY SAND, as above, γ_d = 110.7 PCF
21.2' – 22.5'	(F)	-	-	-	-	-	-	SAMPLE LOST (F.C.)
22.5' – 24.5'	SC-SM	-	-	-	-	-	-	SILTY CLAYEY SAND, dark reddish-brown, damp, est. 70-75% medium grained sand, est. 25-30% medium plasticity fines, medium density, micaceous
24.5' – 26.6'	SC	0	57	43	26	12	13	CLAYEY SAND, brown, very fine to medium, subangular to subrounded grained sand, firm, non-cemented
26.6' – 29.2'	SM	1	62	37	-	-	-	SILTY SAND, brown, moist, very fine to medium, subangular to subrounded grained sand, high plasticity fines, firm, non-cemented
29.2' – 31.5'	SC	1	61	36	25	11	13	CLAYEY SAND, brown, moist, very fine to medium, subangular to subrounded grained sand, firm, non-cemented, γ_d = 120.7 PCF
31.5' – 33.6'	CL	0	36	62	29	11		SANDY CLAY, brown, moist, very fine to medium, subangular to subrounded grained sand, firm, non-cemented, G_s = 2.71
33.6' – 35.6'	(SM)	-	-	-	-	-	-	SILTY SAND, brown, moist, non-cemented (F.C.)
35.6' – 37.9'	SM	0	50	50	-	-	14	SILTY SAND, dark brown to gray, very fine to medium grained sand, firm, non-cemented, breaks in lumps, γ_d = 121.0 PCF
37.9' – 39.9'	SM	0	57	43	19	3	-	SILTY SAND, very fine to medium grained sand
39.9' – 42.0'	ML	0	36	64	-	-	24	SAND SILT, dark gray, very fine to fine grained sand, very loose to loose, non-cemented, γ_d = 101.3 PCF
42.0' – 42.5'	(F)	-	-	-	-	-	-	SAMPLE LOST (F.C.)
42.5' – 44.6'	SM	0	76	22	-	-	-	SILTY SAND, dark gray to tan, very fine to medium, subangular to subrounded grained sand, non to low plasticity fines, est. 5% subrounded gravel to 1/2" size observed in field, very loose to loose, non-cemented
44.6' – 45.6'	(F)	-	-	-	-	-	-	SAMPLE LOST, material saturated, loose (F.C.)
45.6' – 46.6'	SM-SC	-	-	-	-	-	-	SILTY GRAVELLY SAND, gray-brown, damp, est. 40-50% graded sand, est. 40-45% hard gravel to 3/4" maximum, est. 10-15% low plasticity fines
46.6' – 48.3'	SC-SW	1	92	7	23	6	13	CLAYEY SAND, tan, very fine to medium angular to round grained sand, very loose, non-cemented, γ_d = 122.9 PCF
48.3' – 49.6'	(SM)	-	-	-	-	-	-	SILTY SAND, grey, saturated, est. 60% very fine to medium grained sand, est. 40% low to medium plasticity fines, loose to firm, non-cemented, micaceous (F.C.)
49.6' – 51.1'	SM-SP	11	61	6	-	-	-	SILTY SAND, very fine to coarse grained sand, gravel to 1/2" maximum
51.1' – 53.5'	SM	0	77	23	-	-	15	SILTY SAND, brown to greenish-gray, very fine to medium, subangular to round grained sand, medium plasticity fines, firm, non-cemented, highly micaceous, γ_d = 122.9 PCF
53.5' – 55.3'	SC	0	59	41	30	9	22	CLAYEY SAND, brown to greenish-grey, very fine to fine grained sand, medium plasticity fines, firm, non-cemented, micaceous
55.3' – 57.6'	SM	0	66	34	-	-	21	SILTY SAND, brown to greenish-grey, very fine to medium grained sand, medium plasticity fines, firm, non-cemented, micaceous, γ_d = 105.1 PCF
57.6' – 60.3'	SC-SM	0	51	49	25	5	17	SILTY CLAYEY SAND, reddish-brown, very fine to medium grained sand, firm, non-cemented, some carbonaceous material, some scattered pieces of white moderately hard material that appears to be granitic
60.3' – 62.2'	SM	0	64	36	-	-	14	SILTY SAND, reddish-brown with mottled areas of greenish-grey, very fine to medium grained sand, high plasticity, γ_d = 119.9 PCF
62.2' – 64.6'	MH	0	35	65	-	-	-	SANDY SILT, brown, damp, high plasticity fines, very fine to medium grained sand, stiff, non-cemented, highly micaceous, abundant carbonaceous material
64.6' – 66.5'	(MH)	-	-	-	-	-	-	SILT, brown, damp, high plasticity fines, stiff, non-cemented, highly micaceous, abundant carbonaceous material (F.C.)
66.5' – 69.0'	SC-SM	0	56	44	25	7	27	SILTY CLAYEY SAND, brown, very fine to medium grained sand, some carbonaceous material
69.0' – 71.5'	ML	0	42	56	-	-	-	SANDY SILT, brown, medium plasticity fines, very fine to fine grained sand, some carbonaceous material
71.5' – 73.9'	SM	5	73	22	-	-	-	SILTY SAND, brown, wet, very fine to coarse, angular to subrounded grained sand, medium plasticity fines, gravel to 3/4" maximum, firm, non-cemented, micaceous

EXISTING EMBANKMENT (0 – 33.6')

FOUNDATION (33.6' – 73.9')

Vertical Scale: 1" = 4'

7 F - 5

EL. 463.0'

Depth		GR	SA	FI	LL	PI	MC	Description
0 – 2.2'	GM	1	62	17	-	-	-	SILTY SAND, grayish-brown, wet, very fine to medium, angular to subangular grained sand, non to low plasticity fines, loose, non-cemented, micaceous, appears to be decomposed granite
2.2' – 4.2'	SC-SM	0	54	46	25	6	14	SILTY CLAYEY SAND, brown, very fine to medium grained sand, soft to firm, non-cemented, micaceous
4.2' – 5.6'	SC-SM	-	-	-	-	-	-	SILTY CLAYEY SAND, dark to very dark brown, damp, est. 70-75% fine to medium grained sand, est. 25-30% low to medium plasticity fines, low density, non-cemented
5.6' – 7.9'	ML	0	45	55	-	-	17	SANDY SILT, reddish-brown, very fine to fine grained sand, very stiff, moderately cemented with white material that also occurs as stringers, abundant natural fractures
7.9' – 8.1'	(SM)	-	-	-	-	-	-	SILTY SAND, brown, wet, est. 60% very fine to fine grained sand, est. 40% low plasticity fines, firm, non-cemented, micaceous (F.C.)
8.1' – 8.8'	(F)	-	-	-	-	-	-	SAMPLE LOST (F.C.)
8.8' – 12.1'	CL	-	-	-	-	-	-	SANDY SILTY CLAY, dark brown, damp, est. 55% medium plasticity fines, est. 45% fine grained sand, soft, low density, non-cemented, micaceous
12.1' – 14.1'	ML	0	40	60	26	3	27	SANDY SILT, reddish-brown, very fine to medium grained sand, firm, non-cemented, micaceous
14.1' – 15.6'	(SM)	-	-	-	-	-	-	SILTY SAND, dark brown, damp to moist, est. 70% very fine grained sand, est. 30% non to low plasticity fines, loose, non-cemented (F.C.)
15.6' – 16.5'	(F)	-	-	-	-	-	-	SAMPLE LOST (F.C.)
16.5' – 17.5'	SM-SC	-	-	-	-	-	-	SILTY CLAYEY SAND, brown, wet, est. 70% fine grained sand, est. 30% medium plasticity fines, micaceous
17.5' – 19.5'	SM-SC	-	-	-	-	-	-	SILTY CLAYEY SAND, dark grey-brown, damp, low density, est. 60-65% fine grained sand, est. 35-40% low to medium plasticity fines, micaceous, γ_d = 96.9 PCF

Drilling stopped—drill mud was observed running out of joints in the concrete wall of the Kern-Friant Canal. This Canal is 18' west of the hole location. Flow was through pervious levee fill deposits.

EXISTING EMBANKMENT (0 – 4.2')

FOUNDATION (4.2' – 19.5')

NOTES:

1. For location of borings, see sheet No. B16.
2. For additional notes and legend, see sheet No. B27.
3. For additional logs of borings in the Big Dry Creek area, see sheet No. B9 - B29.

GRAPHIC SCALE

1" = 4' 0 1 2' 4' 8' 12' 16' 20'

REVISION	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DESIGNED: K. Swanson
DRAWN: K. Wohl
CHECKED: D. Anderson
SUBMITTED: CHIEF, SOILS DESIGN SECTION

REDBANK AND FANCHER CREEKS, CALIFORNIA
BIG DRY CREEK
BIG DRY CREEK DAM
LOGS OF EXPLORATIONS
7F-3 thru 7F-5

DATE APPROVED:
SCALE:
SHEET B28 / 36
FILE No. SJ-11-20-11

ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING

7 F - 6

EL. 465.0'

Depth		GG	SA	FI	LL	PI	MC	Description	
0	SM	6	76	18	-	-	-	SILTY SAND, dark brown, damp, very fine to coarse grained sand, gravel to 3/4" maximum, micaceous	EXISTING EMBANKMENT
2.3' / 2.7'		-	-	-	-	-	-	CLAYEY GRAVELLY SAND, brown, damp, est. 70-75% graded sand, est. 15% hard gravel to 2" maximum, est. 10-15% low plasticity fines, medium density	
3.3' / 3.7'	SC	-	-	-	-	-	-	CLAYEY SAND, dark brown, est. 65-70% medium grained sand, est. 30-35% medium plasticity fines, medium density	
5.5' / 5.7'	(F)							CLAYEY SAND, as above except with an est. 5% gravel	
		0	72	26	-	-	-	CLAYEY SAND, reddish-brown, damp, est. 60-65% medium grained sand, est. 30-35% medium plasticity fines, est. 5% moderately hard gravel to 1" maximum	FOUNDATION
7.6'	SM	0	62	36	-	-	12	DECOMPOSED GRANITE, hard (F.C.)	
								SILTY SAND, brown, damp, very fine to coarse grained sand, low plasticity fines, very firm to dense, non to slightly cemented	
10.0'	CL	-	-	-	-	-	-	SILTY SAND, brown, wet, very fine to coarse grained angular to subangular sand, low to medium plasticity fines, loose to firm, non-cemented	
11.4'	SM	16	38	26	-	-	-	SANDY CLAY, dark brown, damp, est. 55% medium plasticity fines, est. 45% medium grained sand, micaceous	
13.3'	(F)							GRAVELLY SILTY SAND, reddish brown to brown, moist, very fine to coarse grained angular to subangular sand, gravel to 3/4" maximum, loose, non-cemented	
13.6'	SC	0	69	44	24	9	17	Sample Lost (F.C.)	
15.7'	SC-SM	0	58	44	22	4	-	CLAYEY SAND, reddish-brown to dark grey, very fine to medium grained angular to subangular sand, non-cemented, dark grey material is highly micaceous, G_s =2.75	
17.4'	(F)	-	-	-	-	-	-	Sample Lost (F.C.)	
20.0'	SP-SM	-	-	-	-	-	-	SILTY CLAYEY SAND, brown, moist, very fine to medium grained sand, non-cemented, highly micaceous	
22.3'	(F)							*SILTY SAND, grey-brown, wet, est. 90% fine to medium grained sand, est. 10% low plasticity fines, micaceous	
22.5'	(GC)	-	-	-	-	-	-	Sample Lost (F.C.)	
								SANDY CLAYEY GRAVEL, brown with grey to white gravel with an iron oxide coat, moist to wet, est. 50% angular to subrounded gravel to 2" maximum (composed of quartz and quartz mica schist), est. 30-40% firm to stiff clay, est. 10-20% very fine to coarse grained angular to subangular sand (composed of weathered granite and quartz mica schist), non-cemented (F.C.)	
24.7'									

7 F - 7

EL. 435.4'

Depth		GG	SA	FI	LL	PI	MC	Description	
0	(F)	-	-	-	-	-	-	Not Sampled (F.C.)	EXISTING EMBANKMENT
3.5'	SC	-	-	-	-	-	-	*CLAYEY SAND, dark brown, moist, est. 75% graded sand, est. 25% low to medium plasticity fines, dense, scattered moderately cemented particles to 3/8" maximum	
6.0'		2	66	32	27	9	13	CLAYEY SAND, medium brown, very fine to coarse grained sand, firm, non-cemented, micaceous	
8.5'		-	-	-	-	-	-	*CLAYEY SAND, dark brown, moist, est. 70% graded sand, est. 30% low to medium plasticity fines, traces of fine gravel to 3/8" maximum, dense, scattered moderately cemented particles to 1/2" maximum	
11.1'		0	58	42	-	-	-	CLAYEY SAND, dark brown, moist, very fine to medium grained sand, dense, moderately cemented	
13.5'		2	53	35	32	11	-	CLAYEY SAND, medium brown to medium red-brown, very fine to medium angular to subangular grained sand, firm to very firm, non-cemented	
16.0'		-	-	-	-	-	17	*CLAYEY SAND, dark brown, est. 60% graded sand, est. 35% medium plasticity fines, traces of fine gravel to 1/2" maximum	
18.6'	(SM)	-	-	-	-	-	-	SILTY SAND, dark to medium yellowish-brown, damp, est. 60% very fine to fine grained sand, est. 20% low plasticity fines, firm to very firm, non-cemented (F.C.)	
21.4'	SM-SC	9	56	32	27	6	-	CLAYEY SAND, dark to yellowish-brown, very fine to medium grained sand, gravel to 1-1/2" maximum, scattered clumps of black carbonaceous material and pale yellowish-brown clay stone	
23.9'		0	33	45	23	6	20	CLAYEY SAND, dark to yellowish-brown, very fine to coarse grained sand, loose, non-cemented	
23.4'	SM	5	53	42	-	-	20	SILTY SAND, dark yellowish-brown, very fine to medium grained sand, gravel to 3/4" maximum, loose, non-cemented	
31.5'		0	63	37	-	NP	6	SILTY SAND, as above except loose to firm	
34.0'	SC	-	-	-	-	-	-	*CLAYEY SAND, very dark grey-brown, damp, est. 30% fine to medium grained sand, est. 40% low to medium plasticity fines, dense	
33.5'	(SM)	-	-	-	-	-	-	SILTY SAND, as at 23.9' depth (F.C.)	FOUNDATION
39.0'	SC	-	-	-	-	-	-	*CLAYEY SAND, very dark grey, moist, est. 35% fine to medium grained sand, est. 35% low to medium plasticity fines, dense	
41.3'	(SM)	-	-	-	-	-	-	SILTY SAND, medium to light brown, damp, est. 70-80% very fine to fine grained sand, est. 20-30% low plasticity fines, loose to firm, non-cemented (F.C.)	
44.2'	SP-SM	37	54	9	-	-	10	SILTY GRAVELLY SAND, medium brown, moist, very fine to coarse subangular to subrounded grained sand, subangular to subrounded gravel to 1" maximum, firm, non- to slightly cemented	
46.8'	SP-SC	7	61	12	59	32	-	CLAYEY SAND, medium reddish-brown, wet, fine to coarse subangular to subrounded grained sand, gravel to 1/2" maximum, firm, non-cemented	
50.3'	(F)	-	-	-	-	-	-	Not sampled due to rocky nature of soil. Drilled with tri-cone bit. (F.C.)	
56.7'	(SM)	-	-	-	-	-	-	SILTY SAND, medium to light brown, damp, est. 70-80% very fine to fine grained sand, est. 20-30% low plasticity fines, firm to very firm, non-cemented, mica flakes (F.C.)	
61.3'	SC	-	-	-	-	-	-	*CLAYEY SAND, reddish-brown, moist, est. 55% fine grained sand, est. 45% medium plasticity fines, dense	
38.9'	(SM)	-	-	-	-	-	-	GRAVELLY SILTY SAND, medium to light brown, moist, est. 30% fine to coarse angular grained sand, est. 20% low plasticity fines, est. 20% fine to coarse angular to subangular quartz and mica schist gravel, slightly to heavily weathered (F.C.)	
33.0'	(F)	-	-	-	-	-	-	Not sampled due to gravelly nature of soil (F.C.)	
70.0'									

Vertical Scale: 1" = 4'

7 F - 8

EL. 436.0'

Depth		GG	SA	FI	LL	PI	MC	Description	
0	(F)	-	-	-	-	-	-	Not Sampled (F.C.)	EXISTING EMBANKMENT
3.6'	SM	6	62	32	-	-	20	SILTY SAND, medium to light brown, very fine to coarse angular to subrounded grained sand, low plasticity fines, gravel to 1/2" maximum, firm, non-cemented	
6.7'	SC	-	-	-	-	-	-	*CLAYEY SAND, dark yellowish-brown, moist, est. 70% fine to medium grained sand, est. 30% medium plasticity fines, firm, non-cemented	
11.9'		6	59	39	25	3	14	CLAYEY SAND, dark yellowish-brown, very fine to medium grained sand, gravel to 1" maximum, firm, non-cemented	
13.9'	ML	0	47	53	25	3	16	SANDY SILT, medium brown, very fine to coarse grained sand, firm, non-cemented	
18.9'	SC	-	-	-	-	-	-	*CLAYEY SAND, dark brown, damp, est. 55% fine to medium grained sand, est. 45% medium plasticity fines, firm, non-cemented	
21.2'	(SM)	-	-	-	-	-	-	SILTY SAND, medium brown, damp, est. 60% very fine to fine grained sand, est. 40% low to medium plasticity fines, firm to stiff, non-cemented (F.C.)	
23.9'	SC	-	59	44	22	11	14	CLAYEY SAND, dark yellowish-brown, very fine to medium grained sand, firm, non-cemented	
28.9'	(SM)	-	-	-	-	-	-	SILTY SAND, yellowish-brown, moist, est. 70-80% very fine grained sand, est. 20-30% low plasticity fines, loose to firm, non-cemented (F.C.)	
31.5'	CL	-	-	-	-	-	16	*SANDY CLAY, dark greyish-brown, est. 55% medium to high plasticity fines, est. 45% graded sand	
34.1'	(SM)	-	-	-	-	-	-	SILTY SAND, dark yellowish-brown, moist, est. 70% very fine to fine grained sand, est. 30% low plasticity fines, loose to firm, non-cemented, micaceous	FOUNDATION
38.6'		-	-	-	-	-	-	SILTY SAND, olive-black, moist, est. 60% very fine to fine grained sand, est. 20% non- to low plasticity fines, loose to firm, non-cemented (F.C.)	
36.5'		-	-	-	-	-	-	SILTY SAND, as at 34.1' depth except wet to saturated, intermixed with layers of SANDY SILT, dark yellowish-brown, saturated, est. 60% low plasticity fines, est. 40% very fine to fine grained sand, stiff to very stiff, moderately cemented	
41.0'	SM	1	54	45	60	24	-	SILTY SAND, light brown with stringers of greyish-orange clay, dry, very fine to medium grained sand, very stiff, slightly cemented	
43.5'	(MH)	-	-	-	-	-	-	SANDY SILT, pale olive to light olive-grey, damp, est. 70% high plasticity fines, est. 30% very fine to fine grained sand, stiff, non-cemented, micaceous (F.C.)	
46.2'	GM	75	10	15	37	6	-	SILTY GRAVEL, pale olive with streaks of iron oxide staining, gravel to 1-1/2" maximum, very fine to coarse grained sand	
49.7'	(F)	-	-	-	-	-	-	MICA SCHIST, medium yellowish-brown, aphanitic to fine grained, very soft, foliated, highly weathered (F.C.)	
50.5'									

NOTES:

1. For Location of Borings see Sheet No. B16 .
2. For Notes and Legend see Sheet No. B27 .
3. For additional Logs of Borings and Trenches in the Big Dry Creek area, see sheet Nos. B 9 - B 28.

GRAPHIC SCALE

1" = 4' 0 2' 4' 8' 12' 16' 20'

REVISION	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

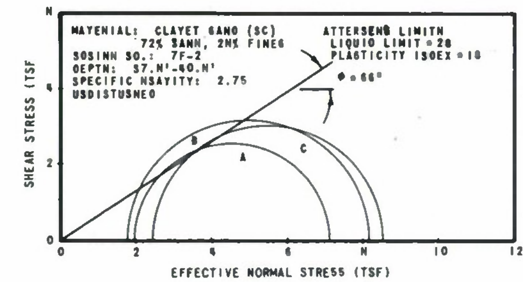
DESIGNED: K. Swanson
DRAWN: K. Wahl
CHECKED: D. Anderson
SUBMITTED: [signature] CHIEF, SOILS DESIGN SECTION

REDBANK AND FANCHER CREEKS, CALIFORNIA
BIG DRY CREEK
BIG DRY CREEK DAM
LOGS OF EXPLORATIONS
7F-6 thru 7F-8

DATE APPROVED: [signature]
SHEET B29 / 37
FILE No. SJ-11-20-11

ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING

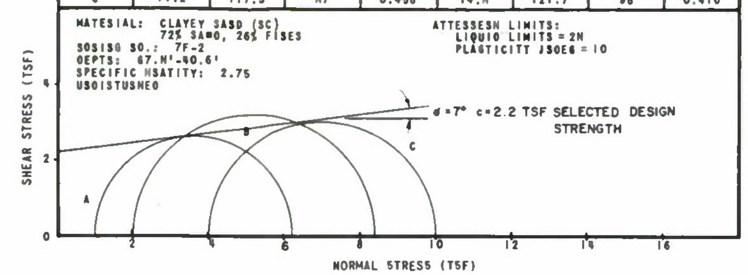
TRIAXIAL COMPRESSION TEST, EFFECTIVE STRENGTH*



*Effective strength based on consolidated undrained strength with pore pressure measurements.

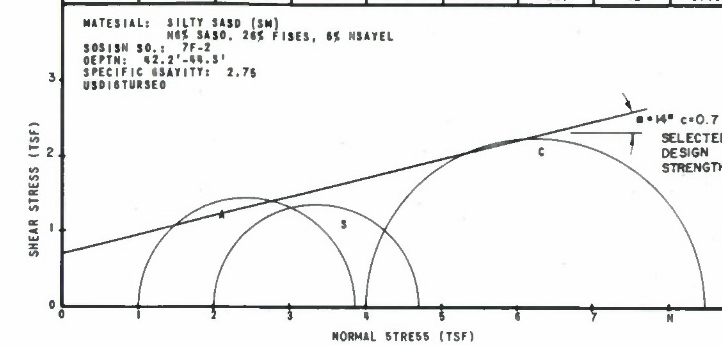
TRIAXIAL COMPRESSION TEST, CONSOLIDATED UNDRAINED (R)

TEST NO.	INITIAL: WATER CONTENT (%)	INITIAL: DRY DENSITY (PCF)	INITIAL: SATURATION (%)	INITIAL: VOID RATIO	BEFORE SHEAR: WATER CONTENT (%)	BEFORE SHEAR: DRY DENSITY (PCF)	BEFORE SHEAR: SATURATION (%)	BEFORE SHEAR: VOID RATIO
A	12.8	114.2	71	0.506	17.3	118.5	100	0.472
B	10.8	117.1	66	0.468	15.5	118.7	85	0.464
C	11.2	117.5	87	0.456	14.8	121.7	96	0.410

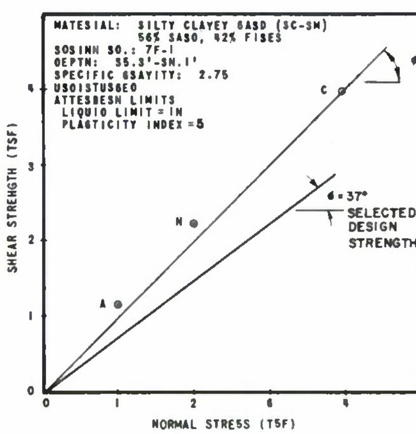


TRIAXIAL COMPRESSION TEST, UNCONSOLIDATED UNDRAINED (Q)

TEST NO.	INITIAL: WATER CONTENT (%)	INITIAL: DRY DENSITY (PCF)	INITIAL: SATURATION (%)	INITIAL: VOID RATIO	BEFORE SHEAR: WATER CONTENT (%)	BEFORE SHEAR: DRY DENSITY (PCF)	BEFORE SHEAR: SATURATION (%)	BEFORE SHEAR: VOID RATIO
A	16.1	116.4	78	0.471	12.8	117.4	78	0.462
B	14.6	115.8	81	0.485	14.2	116.6	82	0.476
C	15.8	121.0	81	0.415	16.6	122.1	82	0.406

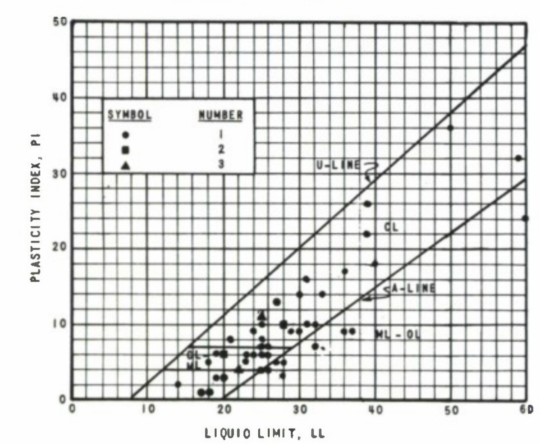


DIRECT SHEAR TEST

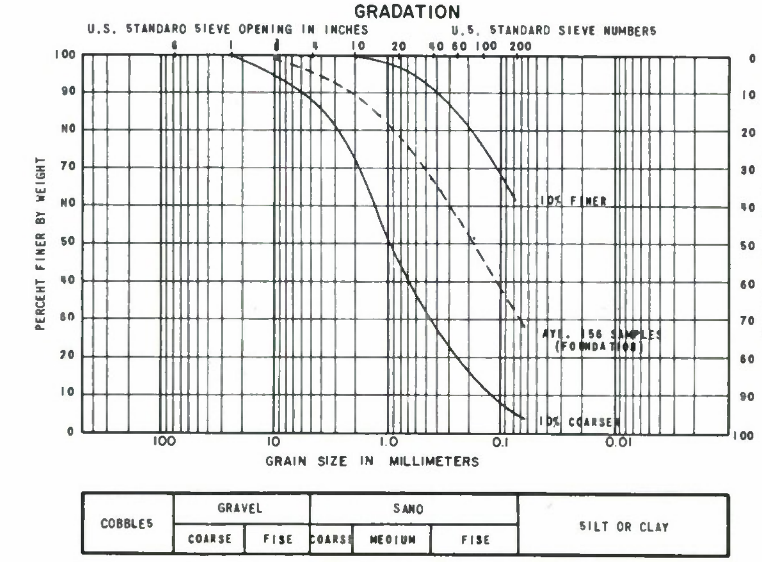


	TEST NO.		A	B	C
INITIAL	WATER CONTENT (%)	w_o	16.4	11.8	11.5
INITIAL	VOID RATIO	e_o	0.460	0.433	0.452
INITIAL	SATURATION (%)	S_o	78	77	71
INITIAL	DRY DENSITY (PCF)	γ_d	117.0	121.5	119.9
	VOID RATIO AFTER CONSOLIDATION	e_c	0.451	0.418	0.460
FINAL	WATER CONTENT (%)	w_f	18.2	15.0	14.6
FINAL	VOID RATIO	e_f	0.463	0.412	0.439
FINAL	SATURATION (%)	S_f	100	100	100

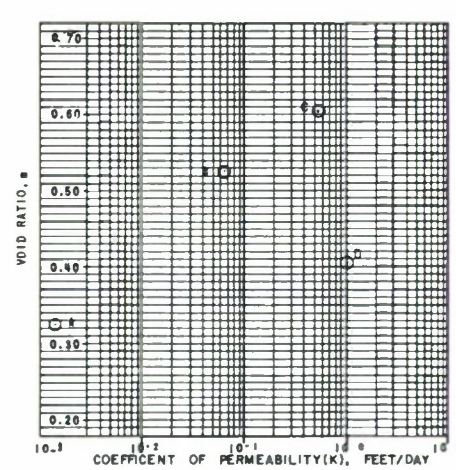
ATTERBERG LIMITS



GRADATION

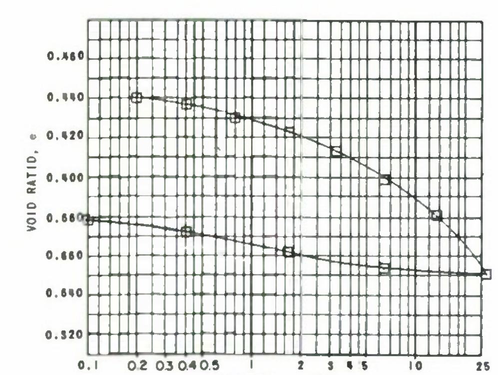


PERMEABILITY



POINT	MATERIAL	BORING NO.	DEPTH (FT)	CONDITION
A	CLAYEY SAND (SC)	7F-2	40.2-42.1	UNDISTURBED
B	SILTY SAND (SM)	7F-4	42.5-44.6	UNDISTURBED
C	SILTY SAND (SM)	2F-11	43.0-45.5	UNDISTURBED
D	SILTY SAND (SM)	2F-11	45.5-47.2	UNDISTURBED

CONSOLIDATION



SYMBOL	MATERIAL	DEPTH (FT) FROM–TO	BORING NO.	P_o (TSF)	P_c (TSF)	C_c	BEFORE TEST: w_o (%)	BEFORE TEST: e_o	BEFORE TEST: S_o	BEFORE TEST: γ_d (%)	AFTER TEST: w_f (%)	AFTER TEST: e_f	AFTER TEST: S_f
⊟	CLAYEY SAND (SC)	43.0	7F-1	2.8	-	-	14.0	0.448	88	118.8	14.0	0.408	100

LEGEND:
- P_o Overburden pressure
- P_c Preconsolidation pressure
- C_c Compression index
- W Water content
- e Void ratio
- S Saturation
- γ_d Dry density

REVISION	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

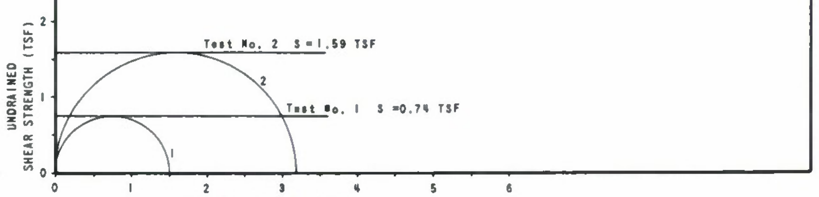
DESIGNED: K. Swanson
DRAWN: K. Wohl
CHECKED: D. Anderson
SUBMITTED: [signature] CHIEF, SOILS DESIGN SECTION

REDBANK AND FANCHER CREEKS, CALIFORNIA
BIG DRY CREEK
BIG DRY CREEK DAM
SUMMARY OF TEST RESULTS
FOUNDATION

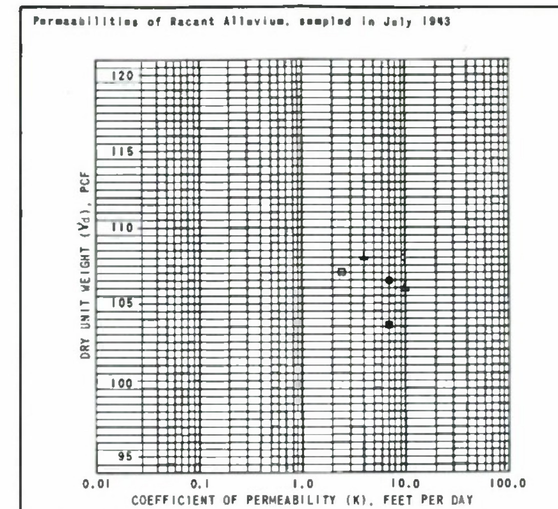
DATE APPROVED: [signature]
SHEET B 30 / 38
FILE No. SJ-11-20-11

UNCONFINED COMPRESSION TEST

TEST NO.	MATERIAL	HOLE NO.	DEPTH (Feet)	ATTERBERG LIMITS		INITIAL CONDITIONS			
				LL	PI	VOID RATIO	SATURATION (%)	DRY DENSITY (PCF)	WATER CONTENT (%)
1	SANDY SILT (ML)	7F-5	12.1-14.1	26	3	0.770	77	96.9	21.5
2	CLAYEY SAND (SC-SM)	7F-6	15.7-17.4	22	4	0.410	75	121.7	11.2



PERMEABILITY



SYMBOL	MATERIAL	HOLE NO.	DEPTH (Feet)	COMPOSITION
△	GRAVELLY SAND (SP)	F-1	5'-11.6'	16% Gravel, 60% Sand, 2% Fines
○	SILTY SAND (SW-SM)	F-1	15'-25'	2% Gravel, 66% Sand, 10% Fines
●	SAND (SP)	F-1	45'-50'	3% Gravel, 93% Sand, 4% Fines
□	SILTY SAND (SM)	F-4	12.5'-17'	3% Gravel, 76% Sand, 21% Fines
▲	SILTY SAND (SM-SP)	F-4	30'-35'	3% Gravel, 91% Sand, 6% Fines
●	CLAYEY GRAVELLY SAND (SC-SM)	F-6	15'-25'	19% Gravel, 72% Sand, 9% Fines

REVISION	DATE	DESCRIPTION	BY	BY
△				
△				

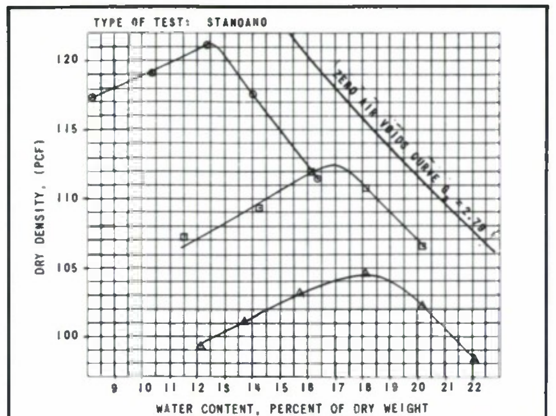
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DESIGNED: K. Swanson
DRAWN: K. Wahl
CHECKED: D. Anderson

REDBANK AND FANCHER CREEKS, CALIFORNIA
BIG DRY CREEK
BIG DRY CREEK DAM
SUMMARY OF TEST RESULTS
FOUNDATION

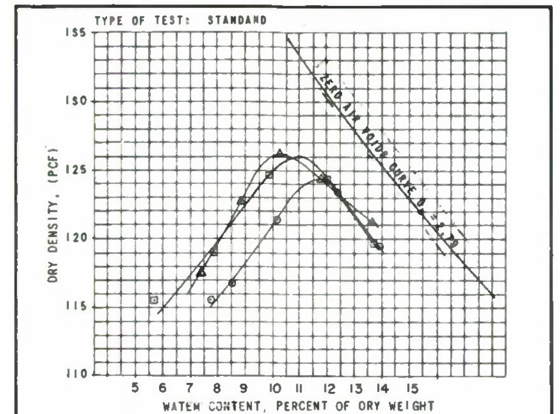
SUBMITTED: CHIEF, SOILS DESIGN SECTION
DATE APPROVED:
SCALE:
SHEET B 31 / 39
FILE No. SJ-11-20-11
SPEC. No.

COMPACTION



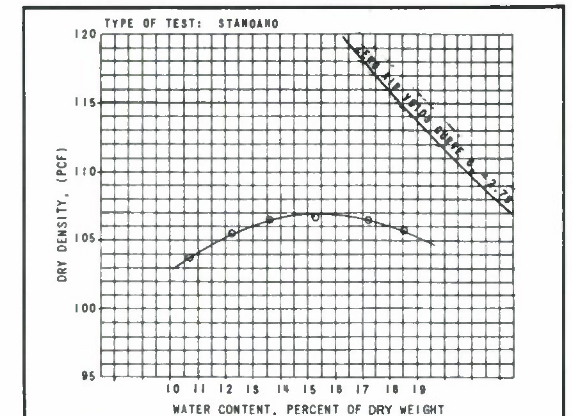
SYMBOL	MATERIAL	HOLE NO.	DEPTH (Ft)	ATTERBERG LIMITS LL	ATTERBERG LIMITS PI	SAMPLE CONTENT	OPTIMUM WATER CONTENT (%)	MAXIMUM DRY DENSITY (PCF)
—⊖—	SILTY SAND (SM)	4F-1	5.0-11.5	-	-	58% SAND 42% FINES	12.5	121.3
—▲—	SILTY SAND (SM)	4F-2	5.0-12.2	28	3	55% SAND 45% FINES	18.1	104.6
—⊟—	SANDY SILT (ML)	4F-3	9.7-12.2	-	-	37% SAND 63% FINES	17.0	112.4

COMPACTION



SYMBOL	MATERIAL	HOLE NO.	DEPTH (Ft)	ATTERBERG LIMITS LL	ATTERBERG LIMITS PI	SAMPLE CONTENT	OPTIMUM WATER CONTENT (%)	MAXIMUM DRY DENSITY (PCF)
—⊖—	SILTY SAND (SM)	4F-4	10.3-12.2	-	-	56% SAND 44% FINES	11.7	124.3
—▲—	CLAYEY SAND (SC)	4F-8	7.0-12.3	21	8	83% SAND 15% FINES 2% GRAVEL	10.2	126.2
—⊟—	SILTY SAND (SM)	4F-8	7.5-12.5	-	-	53% SAND 47% FINES	11.0	126.0

COMPACTION



SYMBOL	MATERIAL	HOLE NO.	DEPTH (Ft)	ATTERBERG LIMITS LL	ATTERBERG LIMITS PI	SAMPLE CONTENT	OPTIMUM WATER CONTENT (%)	MAXIMUM DRY DENSITY (PCF)
—⊖—	SILTY SAND (SM)	4F-7	11.0-12.8	-	-	58% SAND 44% FINES	15.7	107.0

LEGEND:

- G_s Specific Gravity
- LL Liquid Limit
- PI Plasticity Index

REVISION | DATE | DESCRIPTION | BY

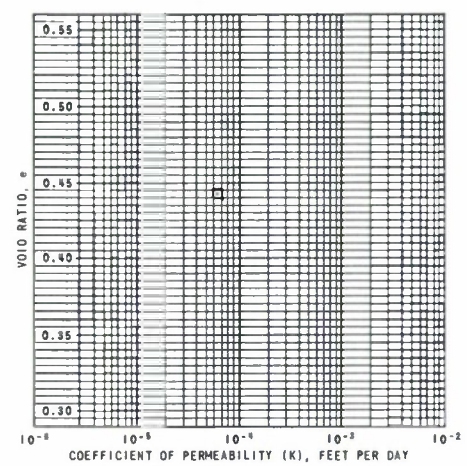
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DESIGNED: K. Swanson
DRAWN: K. Wohl
CHECKED: D. Anderson
SUBMITTED: CHIEF, SOILS DESIGN SECTION

REDBANK AND FANCHER CREEKS, CALIFORNIA
BIG DRY CREEK
BIG DRY CREEK DAM
SUMMARY OF TEST RESULTS
FOUNDATION

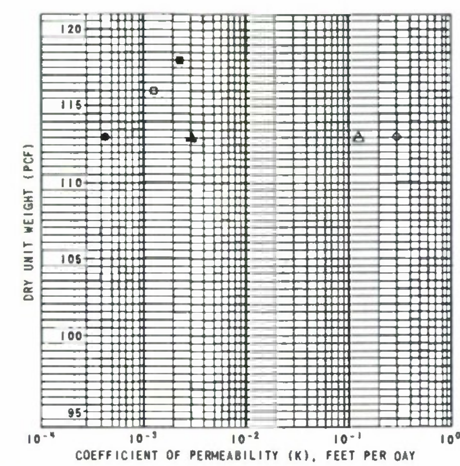
DATE APPROVED
SCALE
SPEC. No.
SHEET B 32 / 40
FILE No. SJ-11-20-11

PERMEABILITY



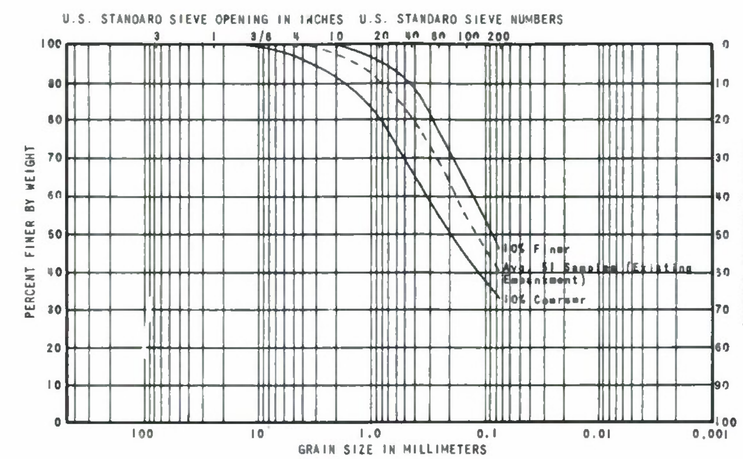
SYMBOL	MATERIAL	HOLE	DEPTH (Feet)	COMPOSITION
□	SANDY CLAY (CL)	7F-4	31.5-33.8	38% Sand, 62% Fines

RECORD PERMEABILITY



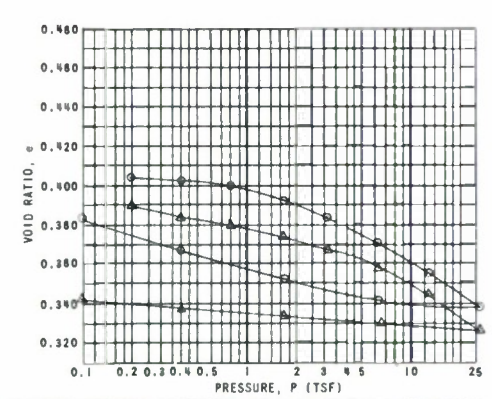
SYMBOL	MATERIAL	STATION	ELEVATION FROM	ELEVATION TO	ATTERBERG LIMITS LL	ATTERBERG LIMITS PI	COMPOSITION SA	COMPOSITION FI	G_s	DRY UNIT WEIGHT (PCF)
△	CLAYEY SAND (SC)	86 + 00	418.4	419.4	29	10	84	38	2.75	113
○	CLAYEY SAND (SC)	80 + 86	423.0	424.0	25	8	57	43	2.75	113
□	CLAYEY SAND (SC)	133+ 30	398.3	399.3	24	10	66	34	2.74	116
●	SILTY CLAYEY SAND (SM-SC)	133 + 33	407.0	408.0	23	7	52	48	2.78	113
▲	CLAYEY SAND (SC)	139 + 23	423.0	424.0	24	9	51	49	2.73	113
■	SILTY CLAYEY SAND (SM-SC)	135 + 54	417.0	418.0	20	7	56	44	2.72	118

GRADATION



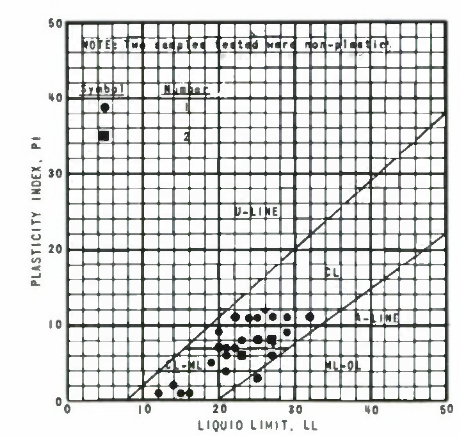
COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

CONSOLIDATION



SYMBOL	MATERIAL	BORING NO.	DEPTH (Feet) FROM	DEPTH (Feet) TO	P_o (TSF)	P_c (TSF)	C_c	Before Test W_o (%)	Before Test e_o	Before Test S_o (%)	Before Test γ_d (PCF)	After Test W_f (%)	After Test e_f	After Test S_f (%)
▲	CLAYEY SAND (SC)	7F-1	15.4	17.9	1.1	-	-	8.6	0.394	61	122.6	12.3	0.371	90
◆	CLAYEY SAND (SC)	7F-2	15.3	18.0	1.1	-	-	12.6	0.405	85	121.7	14.2	0.402	97

ATTERBERG LIMITS



REVISION	DATE	DESCRIPTION	BY	BY
△				
△				

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DESIGNED: K. Swanson
DRAWN: K. Wahl
CHECKED: D. Anderson

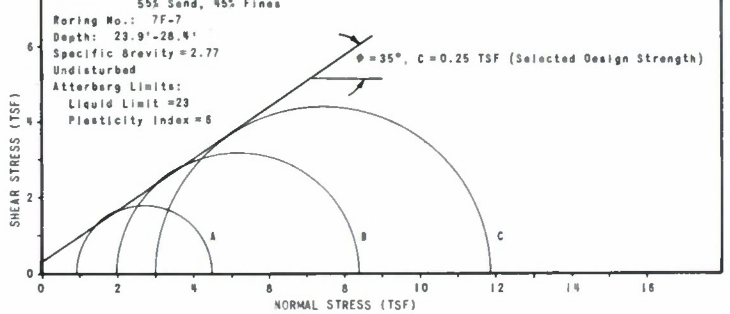
REDBANK AND FANCHER CREEKS, CALIFORNIA
BIG DRY CREEK
BIG DRY CREEK DAM
SUMMARY OF TEST RESULTS
EMBANKMENT

SUBMITTED: [signature]
CHIEF, SOILS DESIGN SECTION
DATE APPROVED: [signature]
SCALE:
SHEET: B33 41
FILE No. SJ-11-20-11
SPEC. No.

TRIAXIAL COMPRESSION TEST, UNCONSOLIDATED UNDRAINED (Q)

TEST NO.	PROPERTIES							
	INITIAL				BEFORE SHEAR			
	WATER CONTENT (%)	DRY DENSITY (PCF)	SATURATION (%)	VOID RATIO	WATER CONTENT (%)	DRY DENSITY (PCF)	SATURATION (%)	VOID RATIO
A	22.4	94.3	74	0.634	22.4	94.8	75	0.624
B	19.6	104.9	64	0.646	19.6	106.0	67	0.629
C	10.9	117.0	63	0.477	10.9	117.2	64	0.474

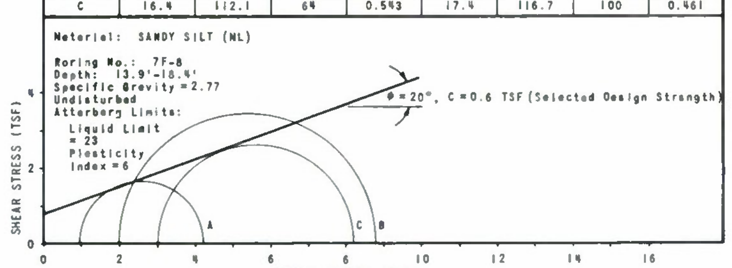
Material: CLAYEY SAND (SC-SM)
55% Sand, 45% Fines
Boring No.: 7F-7
Depth: 23.9'-28.4'
Specific Gravity = 2.77
Undisturbed
Atterberg Limits:
Liquid Limit =23
Plasticity Index = 6



TRIAXIAL COMPRESSION TEST, CONSOLIDATED UNDRAINED (R)

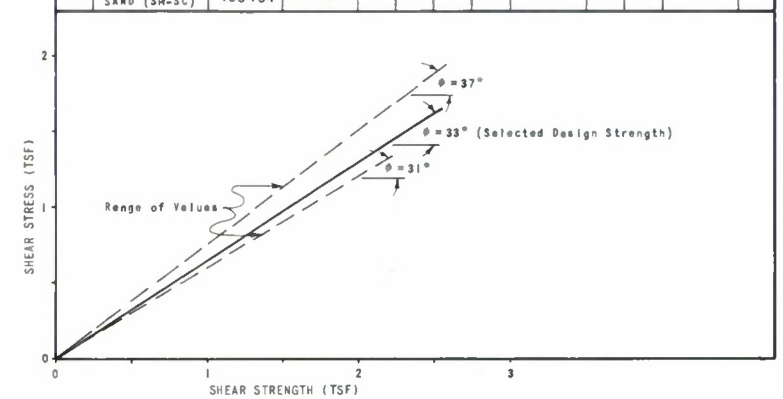
TEST NO.	PROPERTIES							
	INITIAL				BEFORE SHEAR			
	WATER CONTENT (%)	DRY DENSITY (PCF)	SATURATION (%)	VOID RATIO	WATER CONTENT (%)	DRY DENSITY (PCF)	SATURATION (%)	VOID RATIO
A	16.6	101.6	74	0.701	23.9	104.1	100	0.661
B	13.7	116.9	79	0.478	16.0	119.8	100	0.443
C	16.4	112.1	64	0.543	17.4	116.7	100	0.461

Material: SANDY SILT (ML)
Boring No.: 7F-8
Depth: 13.9'-18.4'
Specific Gravity = 2.77
Undisturbed
Atterberg Limits:
Liquid Limit = 23
Plasticity Index = 6



DIRECT SHEAR *

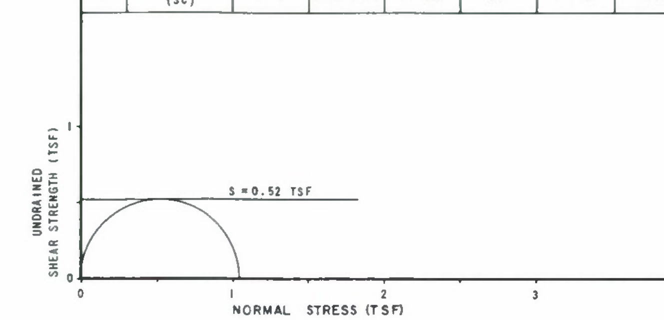
TEST NO.	MATERIAL	STATION	ELEVATION (Feet)	COMPOSITION		ATTERBERG LIMITS		DRY DENSITY (γ_{d_o}) (PCF)	MOISTURE CONTENT		SPECIFIC GRAVITY (-No. 4)	φ
				SA	FI	LL	PI		W_o	W_f		
1	SILTY SAND (SM)	143+68	419.6-420.6	56	44	--	NP	116	6	13	2.72	37
2	SILTY CLAYEY SAND (SM-SC)	110+18	411.0-412.0	61	39	21	6	111	9	17	2.75	34
3	SILTY CLAYEY SAND (SM-SC)	97+33	418.7-417.7	55	45	21	7	106	16	25	2.73	33
4	CLAYEY SAND (SC)	97+39	423.2-424.2	55	45	33	11	112	7	11	2.73	33
5	SILTY CLAYEY SAND (SM-SC)	116+65	413.5-414.5	78	24	20	6	110	11	17	2.74	34
6	CLAYEY SAND (SC)	88+00	416.4-413.4	64	38	29	10	100	15	20	2.73	37
7	CLAYEY SAND (SC)	80+86	423.0-424.0	57	43	25	8	103	14	16	2.75	31
8	CLAYEY SAND (SC)	133+00	398.3-399.3	68	34	24	10	111	12	17	2.74	33
9	SILTY CLAYEY SAND (SM-SC)	139+99	407.0-408.0	52	48	23	7	105	19	23	2.78	31
10	CLAYEY SAND (SC)	139+23	423.0-424.0	51	49	24	9	110	15	19	2.73	32
11	SILTY CLAYEY SAND (SM-SC)	135+54	417.0-418.0	58	44	20	7	114	13	16	2.72	32



* Direct shear results shown were from construction control information

UNCONFINED COMPRESSION TEST

TEST NO.	MATERIAL	HOLE NO.	DEPTH (Feet)	INITIAL CONDITIONS			
				VOID RATIO	SATURATION (%)	DRY DENSITY (PCF)	WATER CONTENT (%)
1	CLAYEY SAND (SC)	7F-7	34.0-36.6	0.458	82	117.9	13.6



REVISION | DATE | DESCRIPTION | BY | BY

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

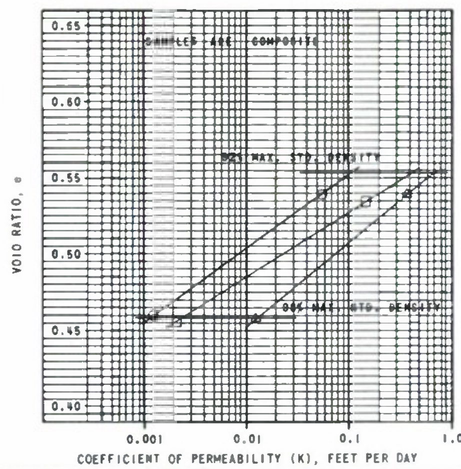
DESIGNED: K. Swanson
DRAWN: K. Wahl
CHECKED: D. Anderson
SUBMITTED:
CHIEF, SOILS DESIGN SECTION

REDBANK AND FANCHER CREEKS, CALIFORNIA
BIG DRY CREEK
BIG DRY CREEK DAM
SUMMARY OF TEST RESULTS
EMBANKMENT

DATE APPROVED:
SCALE:
SHEET B 34
42
FILE No.
SPEC. No.
SJ-11-20-11

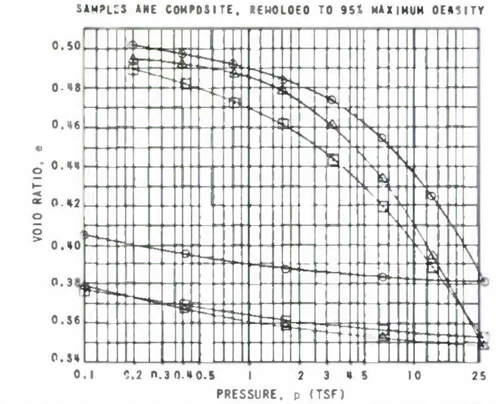
PERMEABILITY

Samples compacted to various percents of Maximum Standard Densities at indicated water contents.



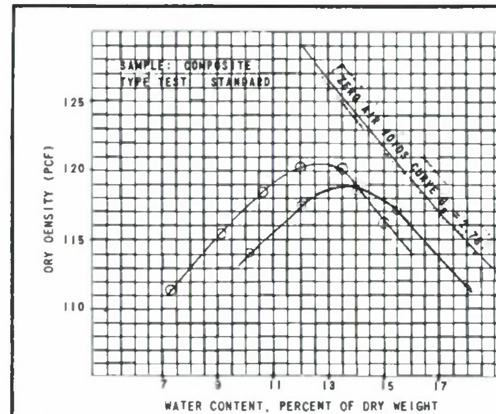
SYMBOL	MATERIAL	HOLE	DEPTH (Ft)	CONDITION
—△—	CLAYEY SAND (SC)	48-1, 3-8	4.1-14.8	OPTIMUM WATER CONTENT
—○—	CLAYEY SAND (SC)	48-1, 3-6	4.1-14.8	OPTIMUM +2%
—□—	CLAYEY SAND (SC)	48-1, 3-6	4.1-14.8	OPTIMUM -2%

CONSOLIDATION



SYMBOL	MATERIAL	BORING NO.	DEPTH (Ft) FROM / TO	P_o (TSF)	P_c (TSF)	C_c	PROPERTIES BEFORE TEST W_o (%)	e_o	S_o (%)	γ_d	AFTER TEST W_f (%)	e_f	S_f (%)
—○—	CLAYEY SAND (SC)	48-1, 3-8	4.1 / 14.8	–	–	–	12.8	0.508	89	114.2	14.0	0.421	92
—□—	CLAYEY SAND (SC)	48-1, 3-6	4.1 / 14.8	–	–	–	14.7	0.502	81	114.8	12.8	0.377	94
—△—	CLAYEY SAND (SC)	48-1, 3-8	4.1 / 14.8	–	–	–	10.3	0.501	57	114.7	13.9	0.406	94

COMPACTION



BORING NO.	MATERIAL	DEPTH (Ft)	SPECIFIC GRAVITY	ATTERBERG LIMITS LL	PI	SAMPLE CONTENT	OPTIMUM WATER CONTENT (%)	MAX. DRY DENSITY (PCF)
48-1, 3-6	CLAYEY SAND (SC)	4-15	2.78	25	9	88% SAND 34% FINES	12.8	120.8
48-12	SANDY CLAY (CL)	2.5-7.5	2.75	30	15	47% SAND 53% FINES	13.8	118.7

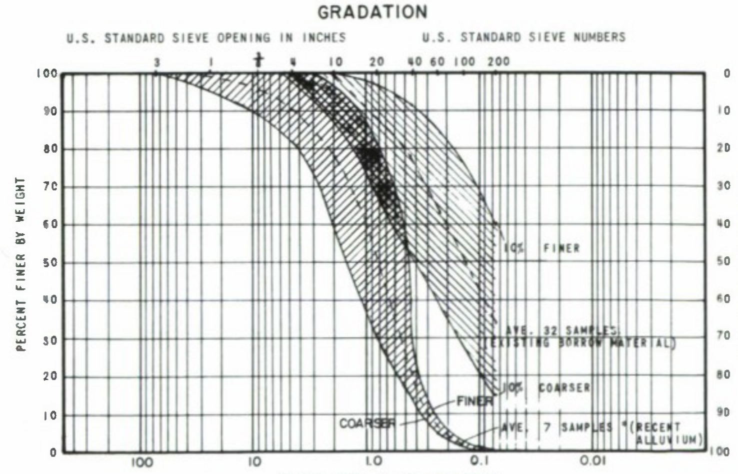
LEGEND:

- G_s Specific gravity (minus no.4)
- P_o Overburden pressure
- P_c Preconsolidation pressure
- C_c Compression index
- W Water content
- e Void ratio
- S Saturation
- γ_d Dry density
- LL Liquid limit
- PI Plasticity index

NOTES:

1. Composite borrow area samples taken from holes 48-1, -3, -4, -5 and -8, depths 4.1' to 14.8'.
2. The gradation of the borrow composite tested is approximately equal to the average gradation shown on the gradation chart of existing borrow material.
3. Fifteen of the eighteen samples used to determine the average gradation of recent Alluvium (Big Dry Creek Bed Deposits) were taken from a 1945 Corps of Engineers Sedimentation Study.
4. Existing Borrow gradations do not include record explorations since material sampled was incorporated into existing Big Dry Creek Dam.

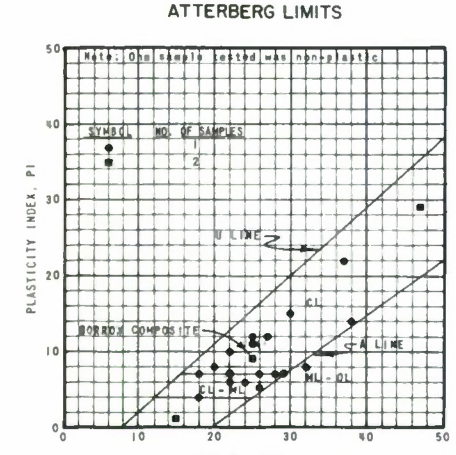
GRADATION



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

* See Note 3

ATTERBERG LIMITS



REVISION	DATE	DESCRIPTION

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

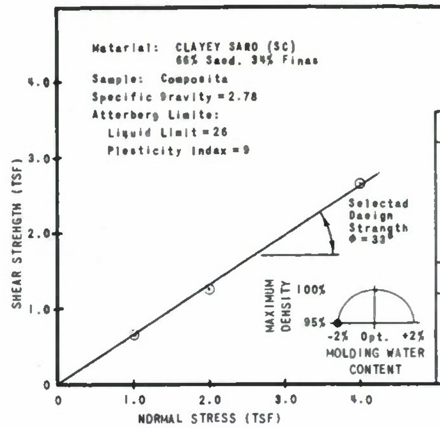
DESIGNED: K. Swenson
DRAWN: K. Wohl
CHECKED: D. Anderson
SUBMITTED:
CHIEF, SOILS DESIGN SECTION

REDBANK AND FANCHER CREEKS, CALIFORNIA
BIG DRY CREEK
BIG DRY CREEK DAM
SUMMARY OF TEST RESULTS
BORROW AREA

DATE APPROVED:
SCALE:
SHEET 6 35 / 43
FILE No. SJ-11-20-11

FUNCTIONAL ANALYSIS - VE PAYS

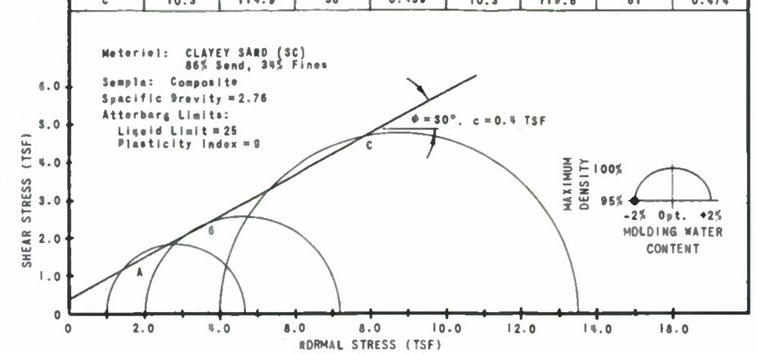
DIRECT SHEAR TEST



	TEST NO.		A	9	C
INITIAL	Water Content (%)	W_o	10.4	10.5	10.4
	Void Ratio	e_o	0.501	0.500	0.502
	Saturation (%)	S_o	57	56	57
	Dry Density (PCF)	γ_d	114.8	114.8	114.7
Void Ratio After Consolidation		e_c	0.493	0.472	0.457
FINAL	Water Content (%)	W_f	19.5	16.8	15.6
	Void Ratio	e_f	0.457	0.435	0.393
	Saturation (%)	S_f	99	99	97

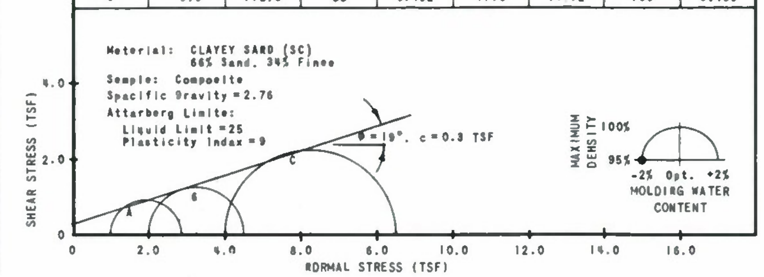
TRIAXIAL COMPRESSION TEST, UNCONSOLIDATED UNDRAINED (Q)

TEST NO.	PROPERTIES							
	INITIAL				BEFORE SHEAR			
	WATER CONTENT (%)	DRY DENSITY (PCF)	SATURATION (%)	VOID RATIO	WATER CONTENT (%)	DRY DENSITY (PCF)	SATURATION (%)	VOID RATIO
A	10.9	114.9	59	0.499	10.6	119.2	91	0.482
6	10.4	114.9	57	0.499	10.4	118.5	80	0.476
C	10.5	114.9	56	0.499	10.5	119.6	61	0.474

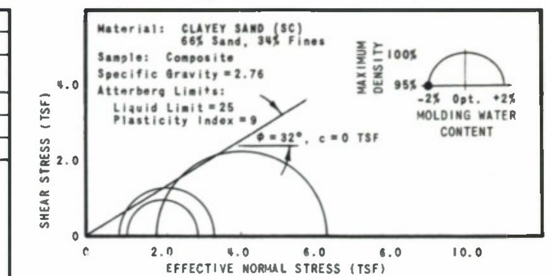


TRIAXIAL COMPRESSION TEST, CONSOLIDATED UNDRAINED (R)

TEST NO.	PROPERTIES							
	INITIAL				BEFORE SHEAR			
	WATER CONTENT (%)	DRY DENSITY (PCF)	SATURATION (%)	VOID RATIO	WATER CONTENT (%)	DRY DENSITY (PCF)	SATURATION (%)	VOID RATIO
A	10.6	114.5	59	0.504	17.9	115.2	96	0.495
6	11.1	114.2	90	0.506	18.0	114.9	99	0.499
C	9.9	115.5	55	0.492	17.0	117.2	100	0.469

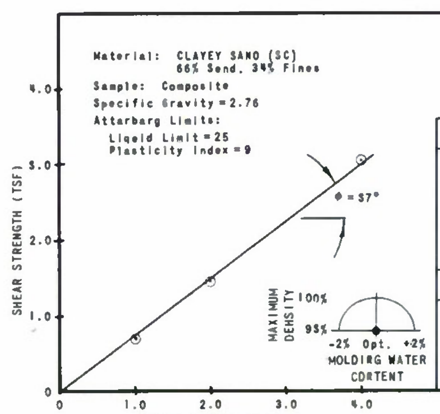


TRIAXIAL COMPRESSION TEST, EFFECTIVE STRENGTH*



NOTE:
All Borrow Area Composites were taken from Trenches 46-1, 3-9, at depths 4.1' to 14.8'. The gradation of the borrow composite tested is approximately equal to the average gradation shown on the gradation chart of existing borrow material, plate .

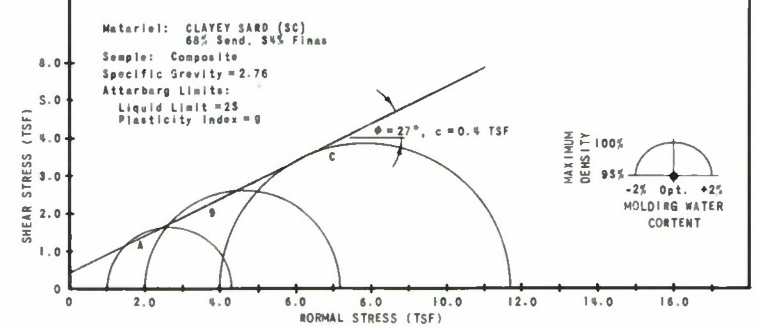
DIRECT SHEAR TEST



	TEST NO.		A	6	C
INITIAL	Water Content (%)	W_o	13.1	12.8	13.0
	Void Ratio	e_o	0.608	0.505	0.506
	Saturation (%)	S_o	71	70	71
	Dry Density (PCF)	γ_d	114.4	114.6	114.4
Void Ratio After Consolidation		e_c	0.489	0.479	0.480
FINAL	Water Content (%)	W_f	17.0	16.1	15.5
	Void Ratio	e_f	0.468	0.454	0.423
	Saturation (%)	S_f	100	96	100

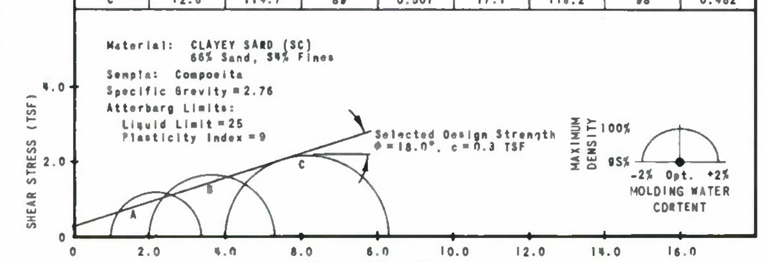
TRIAXIAL COMPRESSION TEST, UNCONSOLIDATED UNDRAINED (Q)

TEST NO.	PROPERTIES							
	INITIAL				BEFORE SHEAR			
	WATER CONTENT (%)	DRY DENSITY (PCF)	SATURATION (%)	VOID RATIO	WATER CONTENT (%)	DRY DENSITY (PCF)	SATURATION (%)	VOID RATIO
A	12.5	114.9	69	0.499	12.5	116.7	72	0.476
6	12.7	114.6	70	0.605	12.7	115.1	71	0.496
C	12.7	114.5	70	0.504	12.7	117.6	78	0.464

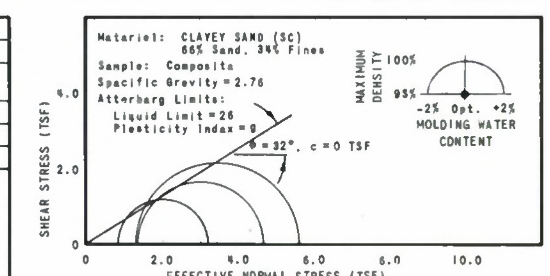


TRIAXIAL COMPRESSION TEST, CONSOLIDATED UNDRAINED (R)

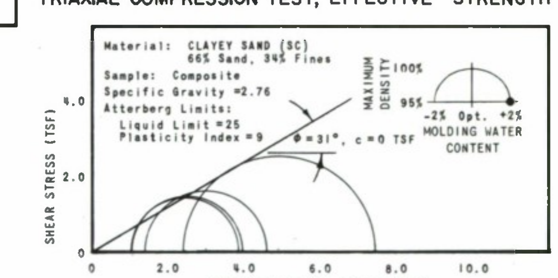
TEST NO.	PROPERTIES							
	INITIAL				BEFORE SHEAR			
	WATER CONTENT (%)	DRY DENSITY (PCF)	SATURATION (%)	VOID RATIO	WATER CONTENT (%)	DRY DENSITY (PCF)	SATURATION (%)	VOID RATIO
A	12.7	114.6	69	0.505	17.9	114.6	96	0.500
6	12.5	114.8	69	0.500	17.6	115.2	99	0.495
C	12.6	114.7	89	0.501	17.1	116.2	98	0.462



TRIAXIAL COMPRESSION TEST, EFFECTIVE STRENGTH*

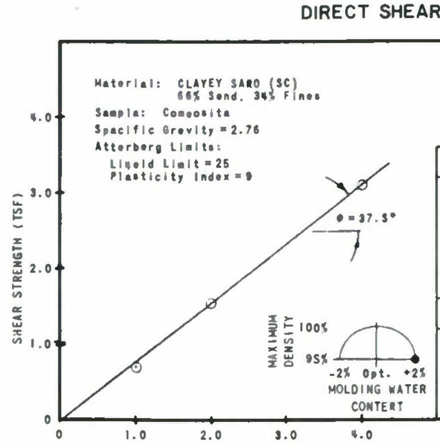


TRIAXIAL COMPRESSION TEST, EFFECTIVE STRENGTH*



*Effective strength based on consolidated undrained strengths with pore pressure measurements.

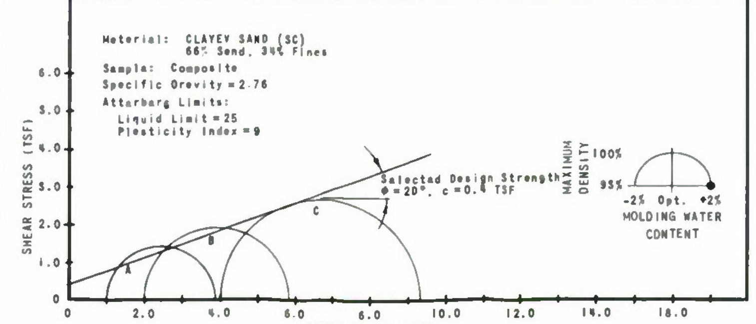
DIRECT SHEAR TEST



	TEST NO.		A	6	C
INITIAL	Water Content (%)	W_o	14.6	15.2	14.6
	Void Ratio	e_o	0.501	0.500	0.498
	Saturation (%)	S_o	61	53	81
	Dry Density (PCF)	γ_d	114.7	114.4	114.9
Void Ratio After Consolidation		e_c	0.491	0.468	0.454
FINAL	Water Content (%)	W_f	16.6	16.3	15.0
	Void Ratio	e_f	0.464	0.439	0.414
	Saturation (%)	S_f	100	66	100

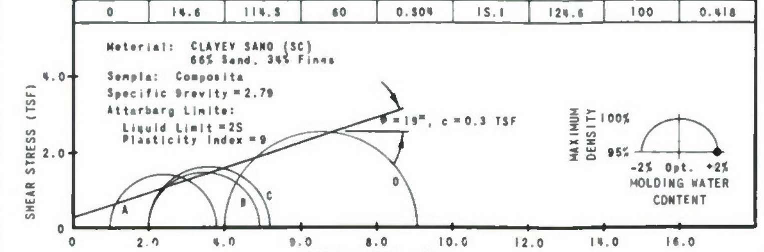
TRIAXIAL COMPRESSION TEST, UNCONSOLIDATED UNDRAINED (Q)

TEST NO.	PROPERTIES							
	INITIAL				BEFORE SHEAR			
	WATER CONTENT (%)	DRY DENSITY (PCF)	SATURATION (%)	VOID RATIO	WATER CONTENT (%)	DRY DENSITY (PCF)	SATURATION (%)	VOID RATIO
A	14.6	114.4	61	0.505	14.6	114.4	61	0.505
6	14.7	114.4	60	0.508	14.7	117.6	68	0.462
C	14.9	114.2	61	0.506	14.9	116.1	92	0.446



TRIAXIAL COMPRESSION TEST, CONSOLIDATED UNDRAINED (R)

TEST NO.	PROPERTIES							
	INITIAL				BEFORE SHEAR			
	WATER CONTENT (%)	DRY DENSITY (PCF)	SATURATION (%)	VOID RATIO	WATER CONTENT (%)	DRY DENSITY (PCF)	SATURATION (%)	VOID RATIO
A	14.6	114.4	61	0.506	16.9	116.9	66	0.475
6	14.7	114.5	61	0.504	17.1	116.2	96	0.462
C	15.1	114.2	62	0.509	17.5	116.0	100	0.464
0	14.6	114.5	60	0.504	15.1	124.6	100	0.418



REVISION	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DESIGNED: K. Swanson
DRAWN: K. Wohl
CHECKED: D. Anderson
SUBMITTED: CHIEF, SOILS DESIGN SECTION

REDBANK AND FANCHER CREEKS, CALIFORNIA
BIG DRY CREEK
BIG DRY CREEK DAM
SUMMARY OF TEST RESULTS
BORROW AREA

DATE APPROVED:
SHEET B 36 / 44
SPEC. No. SJ-11-20-11

Slice No.	Area of Slice (Sq Ft)	Moist Unit Weight (PCF)	Slice Weight (Kips)	Base Length of Slice ΔL (Ft)	cΔL (Kips)	cΔL / F.S.	ϕ_D*
1	18.0	129	2.3	13.9	7.0	3.3	9.83 (9°50')
2	47.6	129	6.1	12.8	6.4	3.0	9.83
3	70.3	129	9.1	12.7	6.4	3.0	9.83
4	79.2	129	10.2	12.2	6.1	2.9	9.83
5	77.1	129	9.9	12.2	6.1	3.1	9.83
6	64.6	129	8.3	11.6	5.8	2.8	9.83
7	38.6	129	5.0	10.2	5.1	2.4	9.83
8	14.1	129	1.8	9.9	5.0	2.4	9.83

$^*\phi_D = \text{Arc tan} \frac{\tan \phi}{F.S.}$

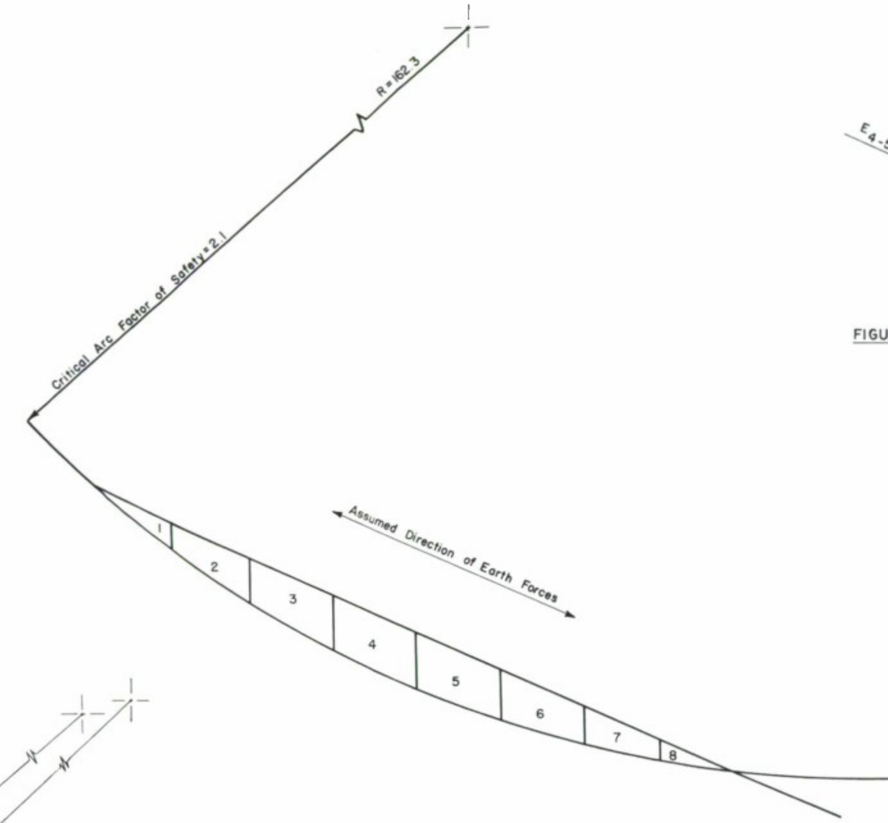


FIGURE 2 - Critical Arc

GRAPHIC SCALE

1" = 10' 0 10' 20' 30' 40' 50'

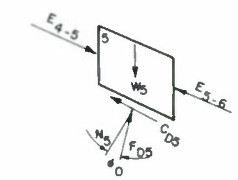
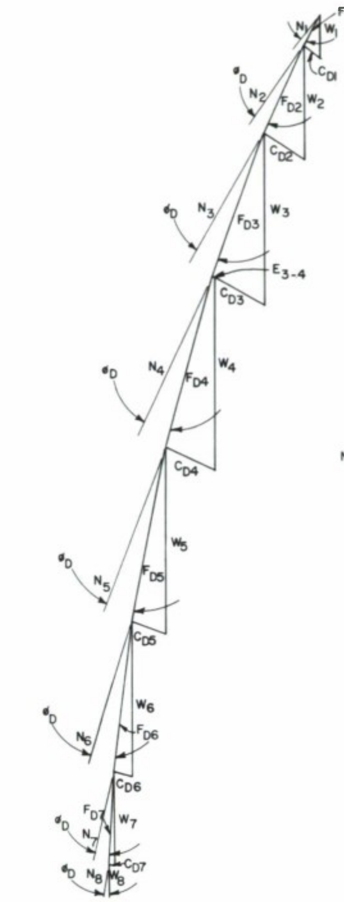


FIGURE 4 - Typical Slice



NOTE: For slices 1, 2, 5-8, it was assumed that the developed shear resistance on the base of the slice can not be greater than that required to close the force polygon.

FIGURE 5 - Composite Force Polygon For Trial F.S. = 2.1

SCALE, Slices 1-8

1" = 2K 0 1K 2K 4K 6K 8K 10K

NOTES:

1. End of Construction analysis for finite slice method performed by Harris Computer System using program no. 741X6L2040 developed by St. Paul District, Corps of Engineers.
2. The computer solution for the critical arc shown was a factor of safety of 2.1. The manual check of this solution confirmed computer results.
3. The seismic condition assumes a horizontal force of 0.10 times the slice weight.

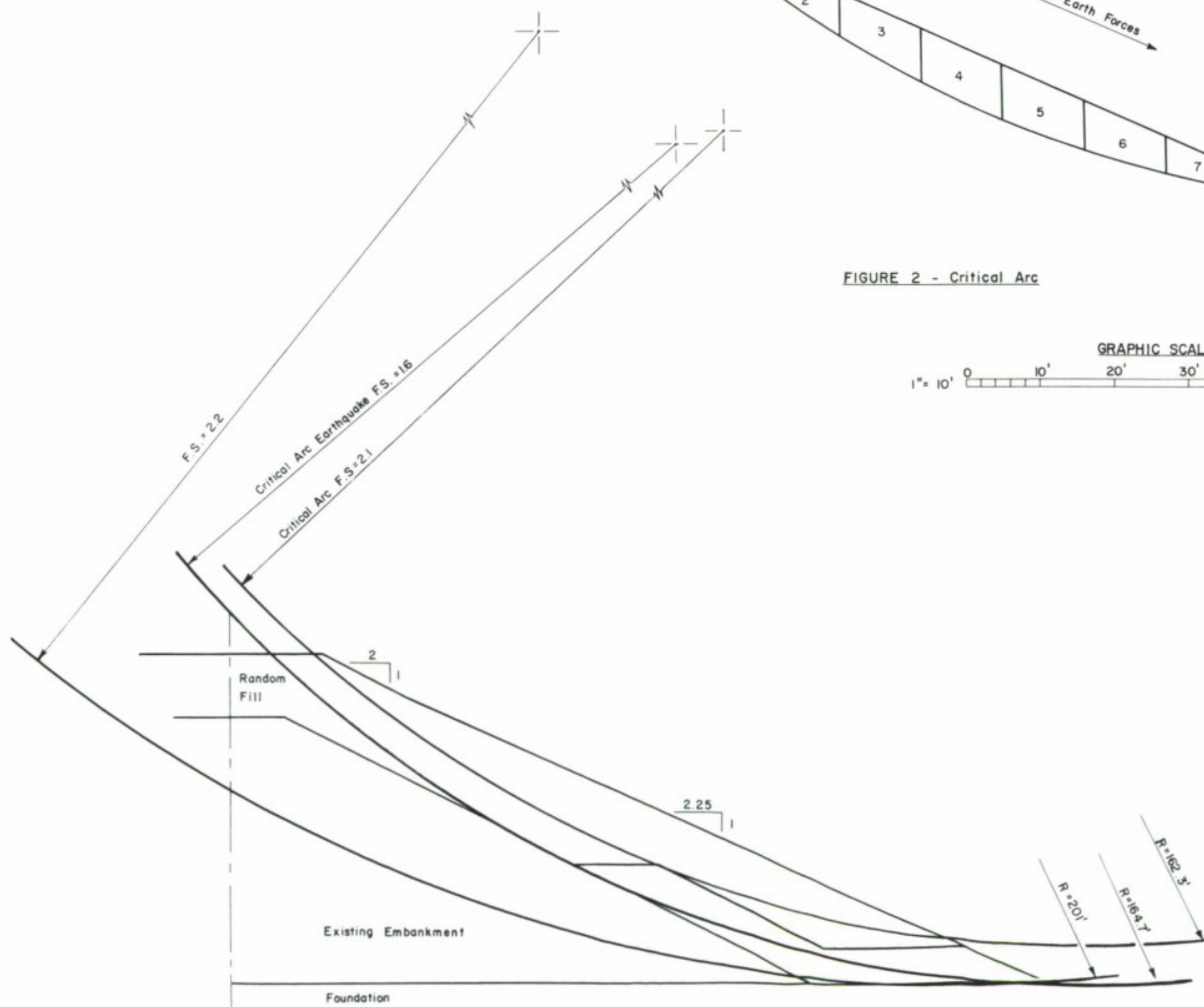


FIGURE 1 - Embankment Section

GRAPHIC SCALE

1" = 10' 0 10' 20' 30' 40' 50'

Material	Q Strength		Unit Weight (PCF)	
	φ Degree	Cohesion Kips/Sq Ft	γ_m	γ_s
Existing Embankment	35	0.5	133	139
Random Fill	20	0.8	129	136
Drainage Fill	34	0	125	130
Foundation	14	1.4	132	135

ADOPTED DESIGN DATA

FIGURE 3 - Design Data

REVISION	DATE	DESCRIPTION	BY	BY

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DESIGNED: K. Swanson
DRAWN: K. Wahl
CHECKED: D. Anderson
SUBMITTED: [signature] CHIEF, SOILS DESIGN SECTION

REDBANK AND FANCHER CREEKS, CALIFORNIA
BIG DRY CREEK

BIG DRY CREEK DAM
STABILITY ANALYSIS
END OF CONSTRUCTION

DATE APPROVED: [signature]
SCALE:
SHEET B 37 / 45
FILE No. SJ-11-20-11
SPEC. No.

Slice No.	Area of Segment (Sq Ft)	Unit Weight γ_m	γ_s	γ_b	Segment Weight (Kips)	Slice Weight (Kips)	Base Length ΔR (Ft)	$c\Delta l$	$\frac{c\Delta l}{FS}$	ϕ_D*
1	48.5	129	-	-	6.26	6.3	11.6	0	-	18
2a	110.8	129	-	-	14.3	-	-	-	-	-
2b	65.2	133	-	-	8.7	23.0	14.4	0	-	18
3a	105.4	129	-	-	13.6	-	-	-	-	-
3b	146.1	133	-	-	19.4	33.0	13.6	0	-	18
4a	108.9	129	-	-	14.0	-	-	-	-	-
4b	134.1	133	-	-	17.8	31.9	11.1	0	-	18
5a	113.3	129	-	-	14.6	-	-	-	-	-
5b	125.2	133	-	-	16.6	31.2	10.8	0	-	18
6a	118.9	129	-	-	15.3	-	-	-	-	-
6b	111.2	133	-	-	14.8	30.1	10.7	0	-	18
7a	118.2	129	-	-	15.2	-	-	-	-	-
7b	5.5	125	-	-	0.7	-	-	-	-	-
7c	89.3	133	-	-	11.9	27.8	10.4	0	-	18
8a	97.1	129	-	-	12.5	-	-	-	-	-
8b	56.1	125	-	-	7.0	-	-	-	-	-
8c	59.8	133	-	-	8.0	-	-	-	-	-
8d	11.9	-	139	76.6	0.9	28.2	12.2	0	-	18
9a	101.6	129	-	-	14.3	-	-	-	-	-
9b	61.9	125	-	-	7.7	-	-	-	-	-
9c	8.5	-	130	67.6	0.6	-	-	-	-	-
9d	7.2	133	-	-	1.0	-	-	-	-	-
9e	21.6	-	139	76.6	1.7	25.3	12.6	0	-	18
10a	110.1	129	-	-	14.2	-	-	-	-	-
10b	37.7	125	-	-	4.7	-	-	-	-	-
10c	42.6	-	130	67.6	2.9	21.8	17.5	0	-	18.64
11a	8.2	129	-	-	1.1	-	-	-	-	-
11b	35.0	125	-	-	4.5	-	-	-	-	-
11c	18.9	-	130	67.6	1.3	6.9	17.7	0	-	18.64

* $\phi_D = \text{Arc tan} \frac{\tan \phi}{F.S.}$

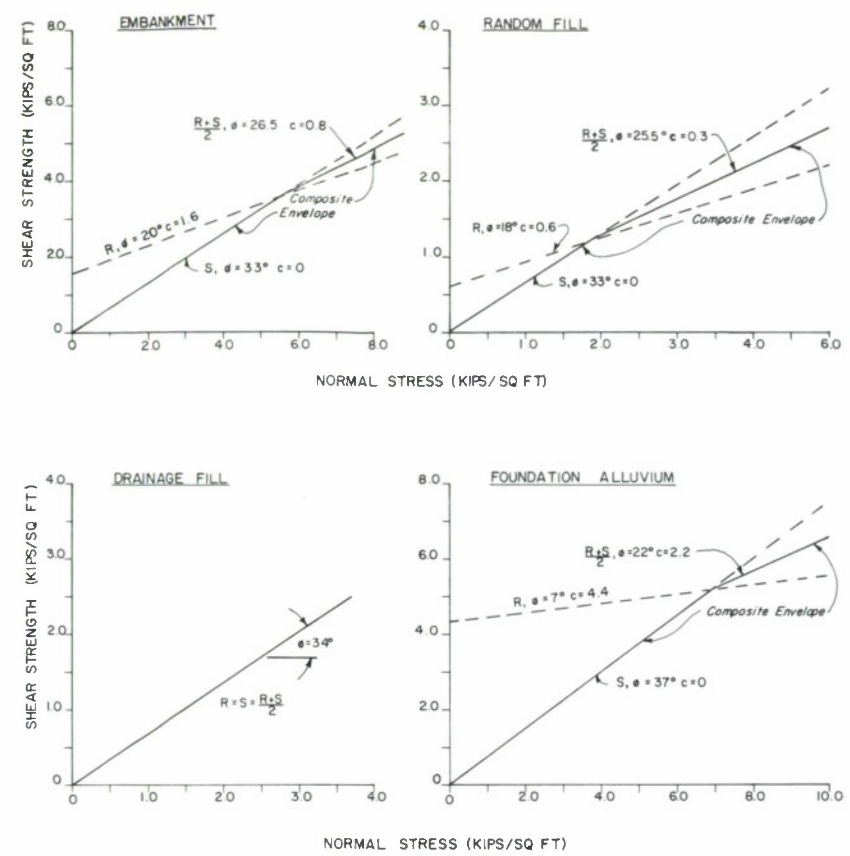


FIGURE 3 - Composite Strength Envelopes

ADOPTED DESIGN DATA						
Material	"S" Strength		"$\frac{R+S}{2}$" Strength		Unit Weights (PCF)	
	ϕ Degree	Cohesion Kips/Sq Ft	ϕ Degree	Cohesion Kips/Sq Ft	γ_m	γ_s
Existing Embankment	33	0	26.5	0.8	133	139
Random Fill	33	0	25.5	0.3	129	136
Foundation Alluvium	37	0	22	2.2	132	135
Drainage Fill	34	0	34	0	130	130

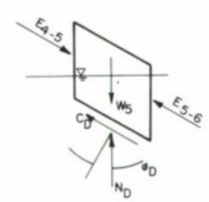


FIGURE 4 - Typical Slice

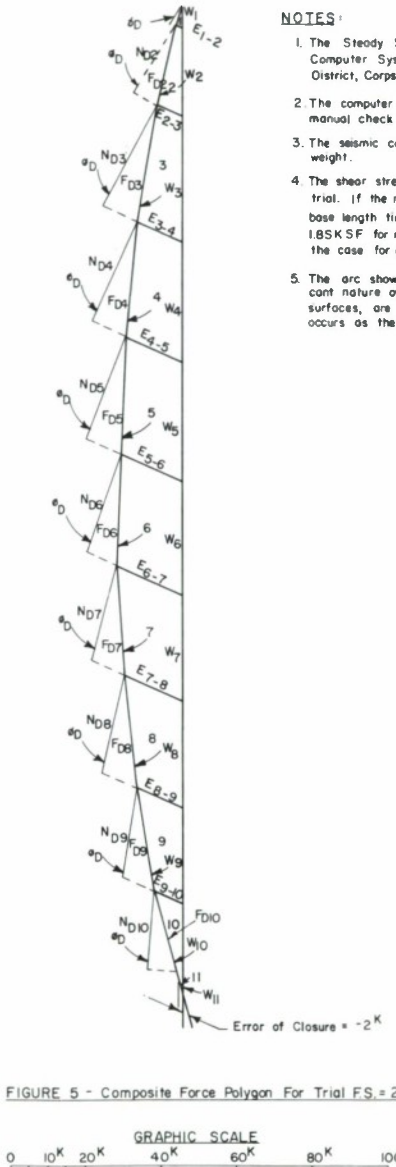


FIGURE 5 - Composite Force Polygon For Trial F.S. = 2.0

NOTES:

1. The Steady Seepage analysis for finite slice method performed by Harris Computer System using program no. 741X6L2040 developed by St. Paul District, Corps of Engineers.
2. The computer solution factor of safety for the selected arc was 2.0. The manual check confirmed the results.
3. The seismic condition assumes a horizontal force of 0.10 times the slice weight.
4. The shear strength used for each slice in the force polygon was selected by trial. If the normal force N_D determined using the "S" strength exceeded the base length times 5.6 KSF for embankment, 7.0 KSF for foundation, or 1.85 KSF for random, the $\frac{R+S}{2}$ strength would have been used. This was not the case for any of the slices.
5. The arc shown, though not the critical arc, was chosen due to the significant nature of the failure. Various arcs typifying the range of failure surfaces, are shown in figure 1. The minimum factor of safety of 1.5 occurs as the failure arc approaches the surface of the embankment.

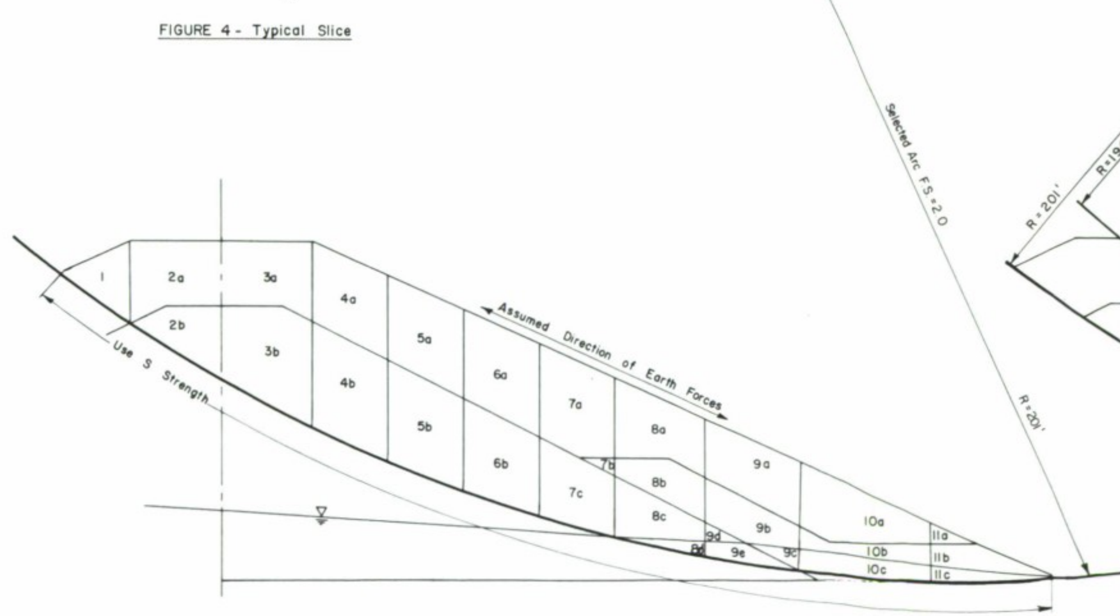


FIGURE 2 - Selected Arc

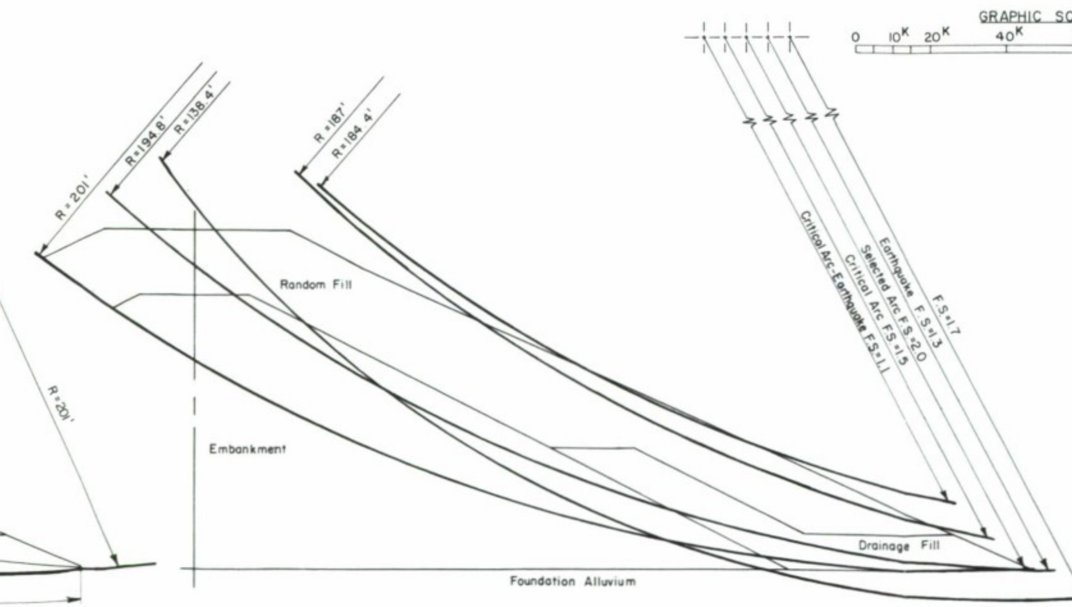


FIGURE 1 - Embankment Section

GRAPHIC SCALE

1"=10' 0 5' 10' 20' 30' 40' 50'

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

REDBANK AND FANCHER CREEKS, CALIFORNIA
BIG DRY CREEK
BIG DRY CREEK DAM
STABILITY ANALYSIS
STEADY SEEPAGE

DESIGNED: K. Swanson
DRAWN: K. Wahl
CHECKED: D. Anderson
SUBMITTED: CHIEF, SOILS DESIGN SECTION
DATE APPROVED:
SHEET B 38 / 46
SJ-11-20-11

Slice No.	Segment No.	Area of Segment (Sq Ft)	γ_m	γ_b	Segment Weight (Kips)	Slice Weight (Kips)	$\triangle l$	ϕ_D*
1	-	45.1	129	-	-	5.8	18.8	19.34
2	-	148.9	129	-	-	19.2	21.3	19.34
3	-	234.1	129	-	-	30.2	21.6	19.34
4	4a	166.3	129	-	21.5	26.1	19.6	19.34
4	4b	63.1	129	73.6	4.6			
5	5a	56.4	129	-	7.3	18.6	18.7	19.34
5	5b	153.2	-	73.6	11.3			
6	-	166.8	-	73.6	-	12.3	17.9	19.34
7	-	91.8	-	73.6	-	6.8	21.3	19.34

*$\phi_D = \text{Arc tan}\ \frac{\tan\phi}{F.S.} = \text{Arc tan}\ \frac{\tan 33°}{1.85} = 19.34$

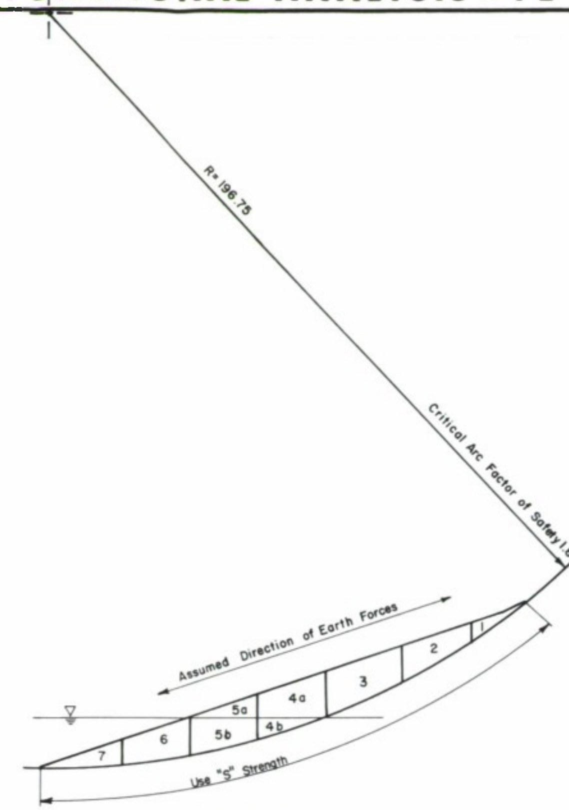


FIGURE 2 - Critical Arc

GRAPHIC SCALE

1" = 20'

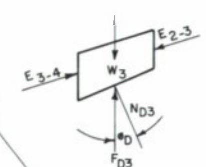


FIGURE 4 - Typical Slice

ADOPTED DESIGN DATA						
Material	"S" Strength		"$\frac{R+S}{2}$" Strength		Unit Weights (PCF)	
	ϕ Degree	Cohesion Kips/Sq Ft	ϕ Degree	Cohesion Kips/Sq Ft	γ_m	γ_b
Existing Embankment	33	0	26.5	0.8	133	76.6
Random Fill	33	0	25.5	0.3	129	73.6
Foundation Alluvium	37	0	22	2.2	132	72.6

FIGURE 3 - Composite Strength Envelopes

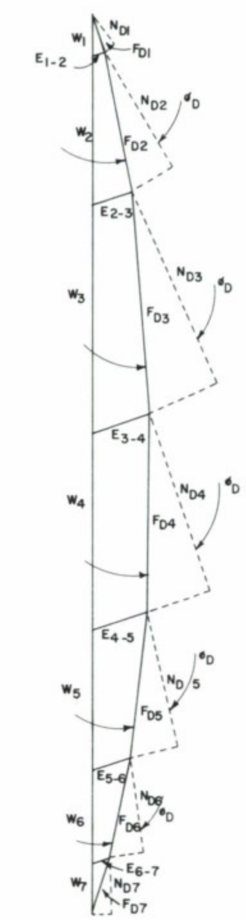


FIGURE 5 - Composite Force Polygon For Trial F.S. 1.85

SCALE, Slices 1-7

1" = 10K

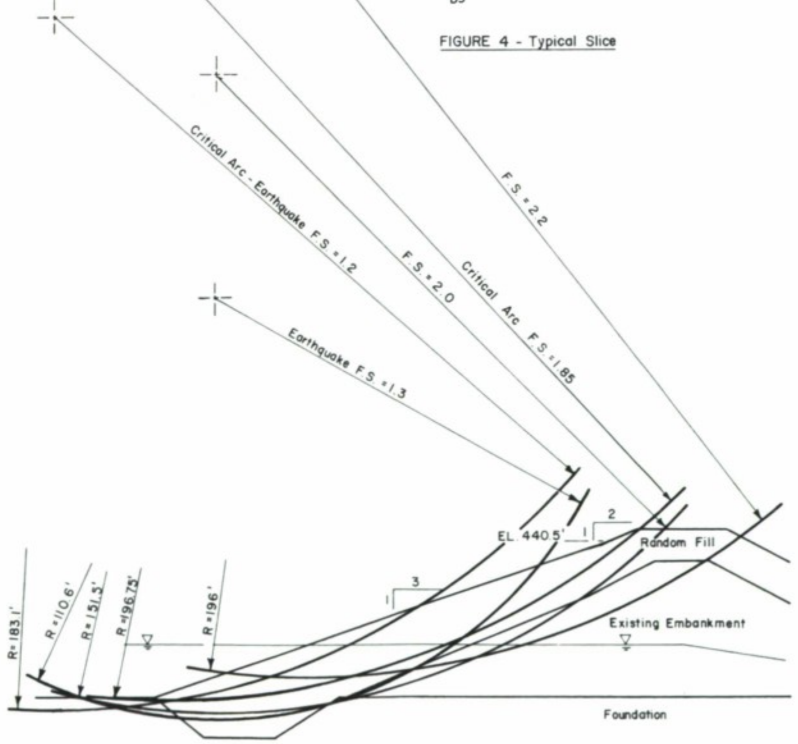


FIGURE 1 - Embankment Section

1" = 20'

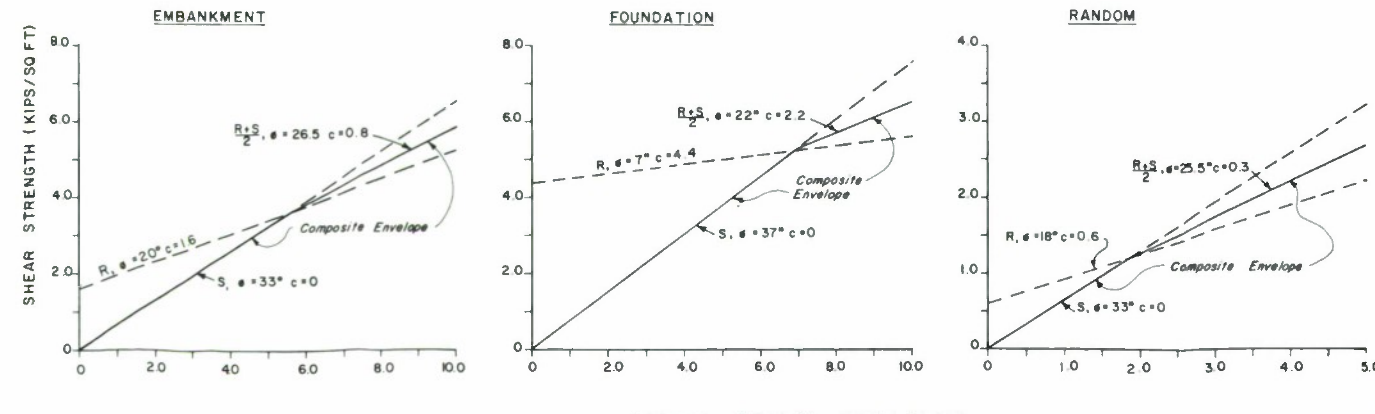


FIGURE 3 - Composite Strength Envelopes

NOTES:

1. The shear strength used for each slice in the force polygon was selected by trial. If the normal force N_D determined using the S strength exceeded 1.85 K.S.F. times the base length of the slice, the R strength would have been used for that slice. This was not the case for any of the slices.
2. Partial Pool analysis for finite slice method performed by Harris Computer System using program no. 741X6L20 developed by St. Paul District, Corps of Engineers.
3. The computer solution for the critical arc shown was a factor of safety of 1.8. The manual check of this solution confirmed the results.
4. The seismic condition assumes a horizontal force of 0.10 times the slice weight.

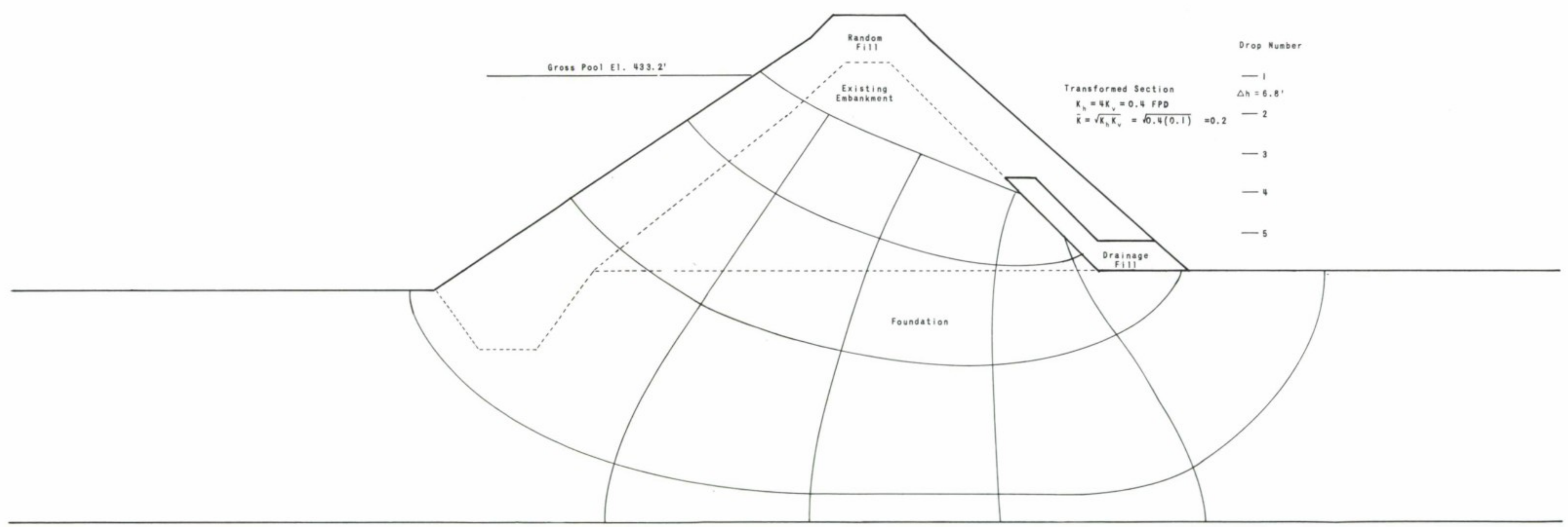
REVISION	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DESIGNED: K. Swanson
DRAWN: K. Wahl
CHECKED: D. Anderson
SUBMITTED: CHIEF, SOILS DESIGN SECTION

REDBANK AND FANCHER CREEKS, CALIFORNIA
BIG DRY CREEK
BIG DRY CREEK DAM
STABILITY ANALYSIS
PARTIAL POOL

DATE APPROVED:
SCALE:
SHEET B 39 / 47
FILE No. SJ-11-20-11



FLOW NET

1" = 20'H
1" = 10'V

SEEPAGE ESTIMATE:

1. Assuming steady state seepage conditions developed, and foundation permeability is equal to embankment permeability, the following total seepage flow can be estimated:

$$Q = \bar{K}H \frac{n_f}{n_d} L = 0.2\,(34)\,\frac{3.25}{5.0}\,(12,450)\ \text{CF/Day}$$

$$= 5.5 \times 10^4\ \text{CF/Day} = 0.64\ \text{CFS}$$

2. Of the total estimated seepage, 62% or 0.47 CFS will be collected in the drain, while 0.29 CFS will be confined to the foundation.

NOTES:

1. The permeability of the foundation is less than that of the embankment; however, in order to simplify the analysis, permeability values were assumed to be equal.
2. The lower seepage boundary was assumed to be located at a depth equal to the height of the embankment. Materials located below this depth are relatively impervious and therefore have little influence on seepage losses.
3. The effective length was taken as the length of dam foundation at or below elevation 425.0'.

GRAPHIC SCALES

Horizontal Scale 1" = 20' 0 5' 10' 20' 40' 60' 80' 100'

Vertical Scale 1" = 10' 0 5' 10' 20' 30' 40' 50'

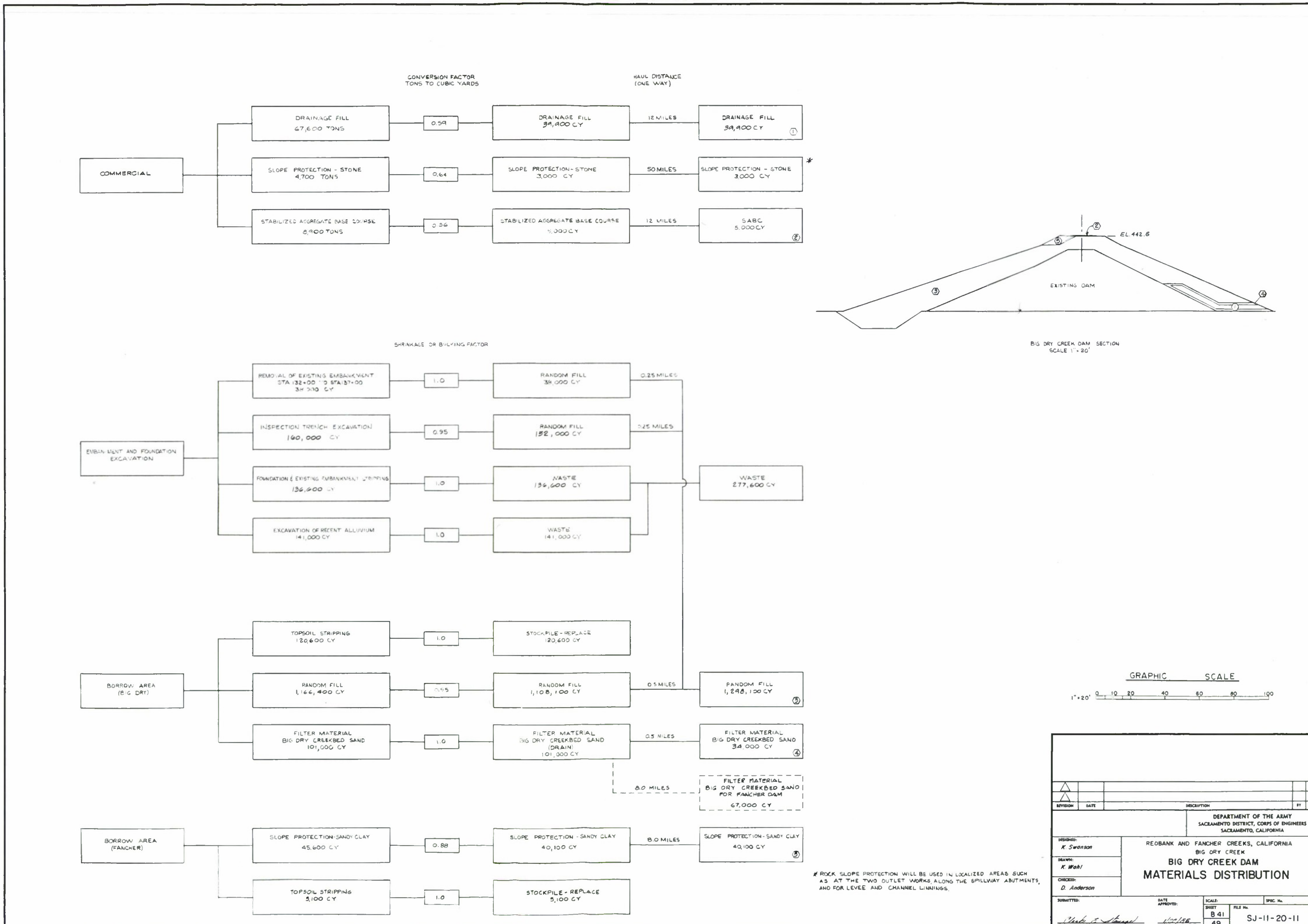
REVISION	DATE	DESCRIPTION	BY	BY

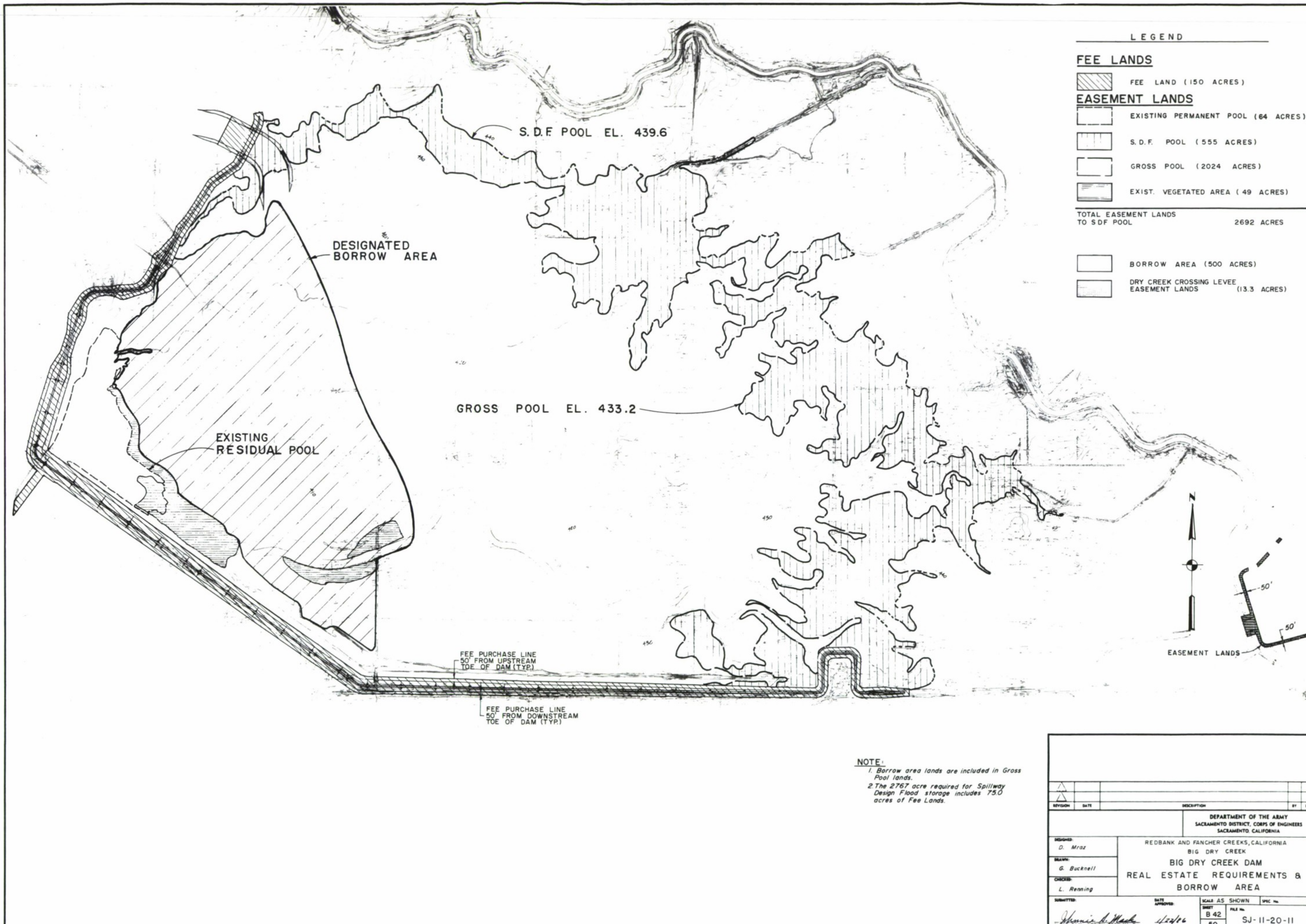
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

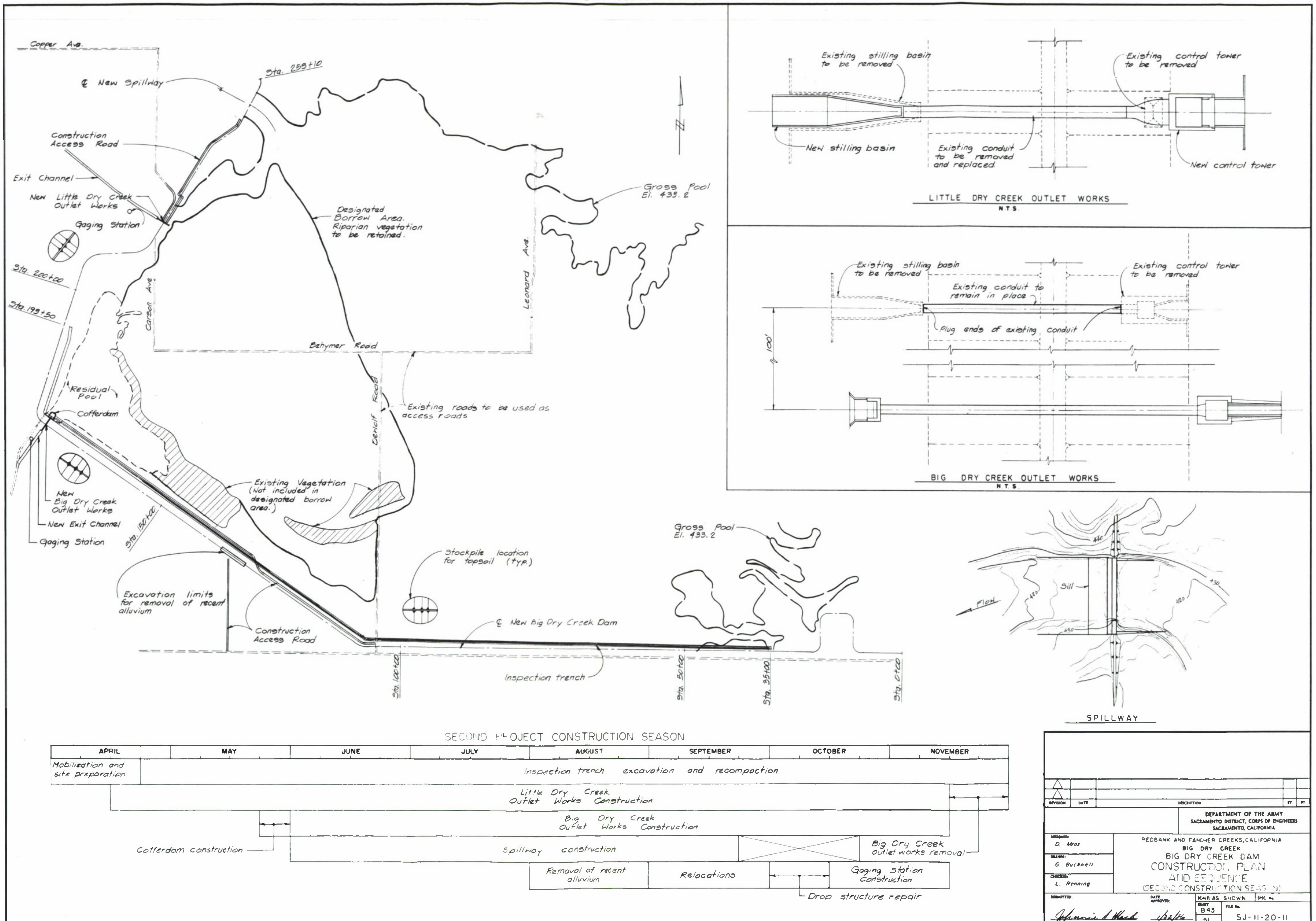
DESIGNED: K. Swanson
DRAWN: K. Swanson
CHECKED: D. Anderson
SUBMITTED:

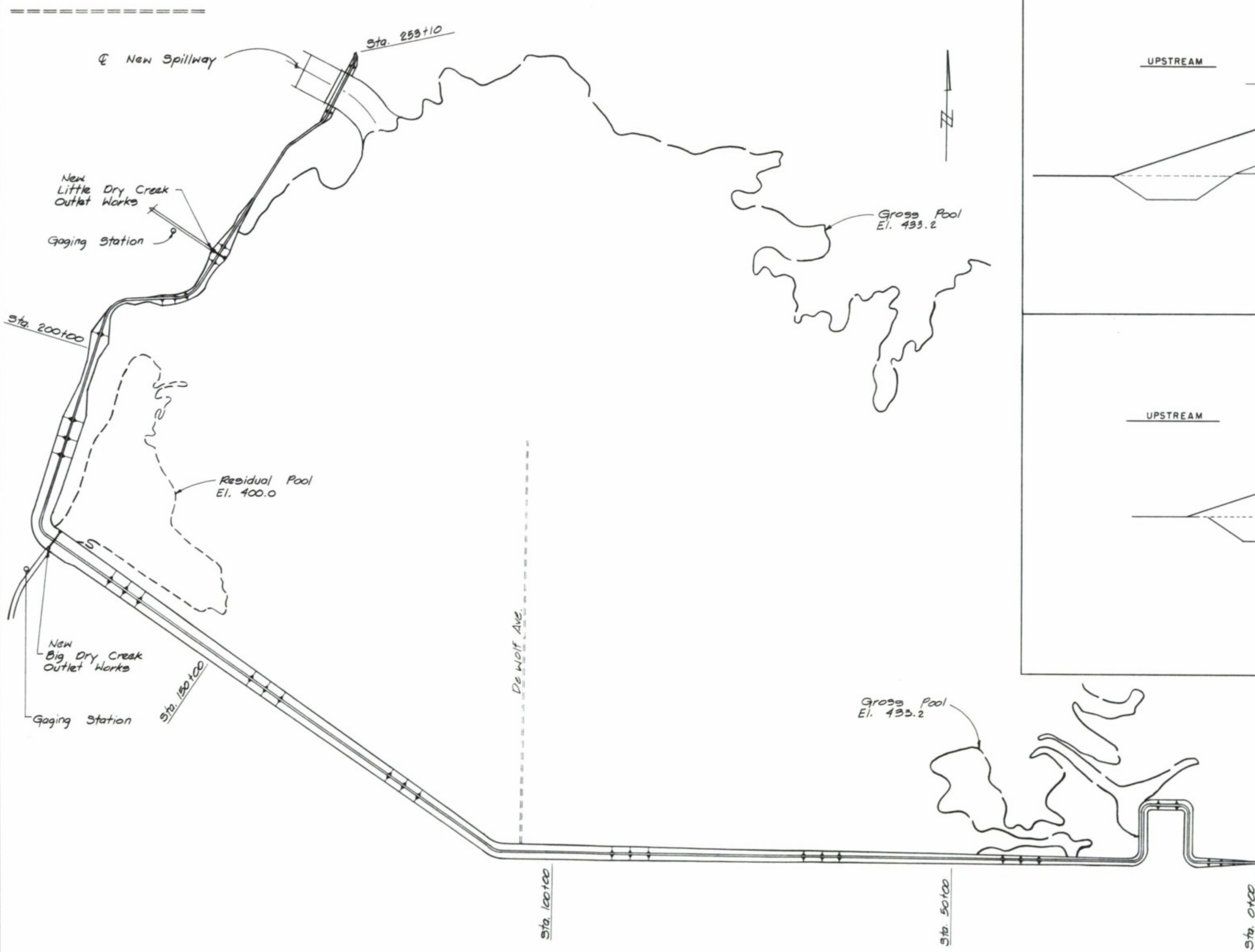
REDBANK AND FANCHER CREEKS, CALIFORNIA
BIG DRY CREEK
BIG DRY CREEK DAM
SEEPAGE ANALYSIS

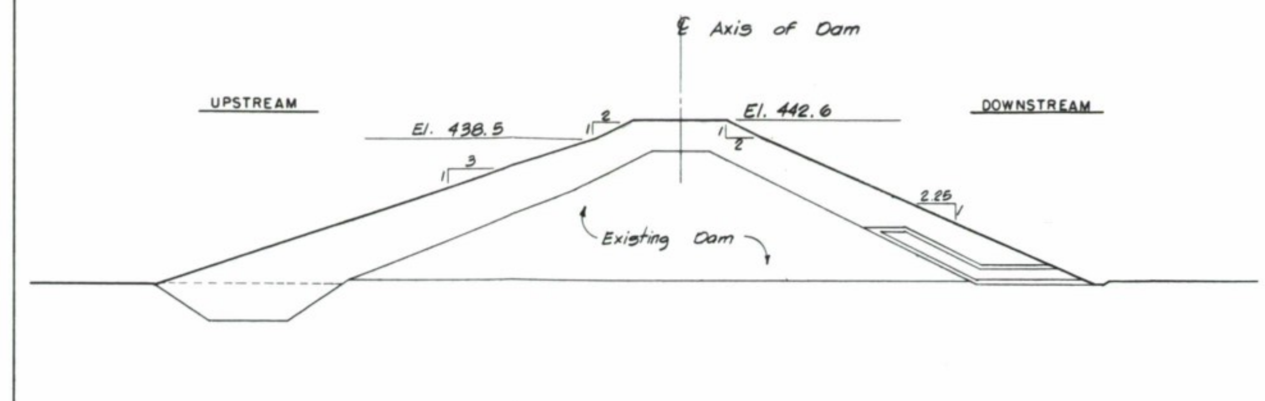
CHIEF, SOILS DESIGN SECTION
DATE APPROVED:
SCALE:
SPEC. No.
SHEET B40 48
FILE No. SJ-11-20-11


CONVERSION FACTOR TONS TO CUBIC YARDS
HAUL DISTANCE (ONE WAY)
COMMERCIAL
DRAINAGE FILL 67,600 TONS
0.59
DRAINAGE FILL 39,900 CY
12 MILES
DRAINAGE FILL 39,900 CY ①
SLOPE PROTECTION - STONE 4,700 TONS
0.64
SLOPE PROTECTION - STONE 3,000 CY
50 MILES
SLOPE PROTECTION - STONE 3,000 CY *
STABILIZED AGGREGATE BASE COURSE 8,900 TONS
0.56
STABILIZED AGGREGATE BASE COURSE 5,000 CY
12 MILES
SABC 5,000 CY ②
SHRINKAGE OR BULKING FACTOR
EMBANKMENT AND FOUNDATION EXCAVATION
REMOVAL OF EXISTING EMBANKMENT STA 132+00 TO STA 137+00 39,000 CY
1.0
RANDOM FILL 39,000 CY
0.25 MILES
INSPECTION TRENCH EXCAVATION 160,000 CY
0.95
RANDOM FILL 152,000 CY
0.25 MILES
FOUNDATION & EXISTING EMBANKMENT STRIPPING 136,600 CY
1.0
WASTE 136,600 CY
WASTE 277,600 CY
EXCAVATION OF RECENT ALLUVIUM 141,000 CY
1.0
WASTE 141,000 CY
BORROW AREA (BIG DRY)
TOPSOIL STRIPPING 120,600 CY
1.0
STOCKPILE - REPLACE 120,600 CY
RANDOM FILL 1,166,400 CY
0.95
RANDOM FILL 1,108,100 CY
0.5 MILES
RANDOM FILL 1,298,100 CY ③
FILTER MATERIAL BIG DRY CREEKBED SAND 101,000 CY
1.0
FILTER MATERIAL BIG DRY CREEKBED SAND (DRAIN) 101,000 CY
0.5 MILES
FILTER MATERIAL BIG DRY CREEKBED SAND 34,000 CY ④
8.0 MILES
FILTER MATERIAL BIG DRY CREEKBED SAND FOR FANCHER DAM 67,000 CY
BORROW AREA (FANCHER)
SLOPE PROTECTION - SANDY CLAY 45,600 CY
0.88
SLOPE PROTECTION - SANDY CLAY 40,100 CY
8.0 MILES
SLOPE PROTECTION - SANDY CLAY 40,100 CY ⑤
TOPSOIL STRIPPING 5,100 CY
1.0
STOCKPILE - REPLACE 5,100 CY
EL 442.6
EXISTING DAM
BIG DRY CREEK DAM SECTION SCALE 1" = 20'
GRAPHIC SCALE
1" = 20' 0 10 20 40 60 80 100
* ROCK SLOPE PROTECTION WILL BE USED IN LOCALIZED AREAS SUCH AS AT THE TWO OUTLET WORKS, ALONG THE SPILLWAY ABUTMENTS, AND FOR LEVEE AND CHANNEL LININGS.
REVISION DATE DESCRIPTION BY
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
DESIGNED: K. Swanson
DRAWN: K. Wahl
CHECKED: D. Anderson
SUBMITTED:
CHIEF, SOILS DESIGN SECTION
REDBANK AND FANCHER CREEKS, CALIFORNIA
BIG DRY CREEK
BIG DRY CREEK DAM
MATERIALS DISTRIBUTION
DATE APPROVED:
SCALE:
SHEET B 41 49
FILE No.
SPEC. No.
SJ-11-20-11

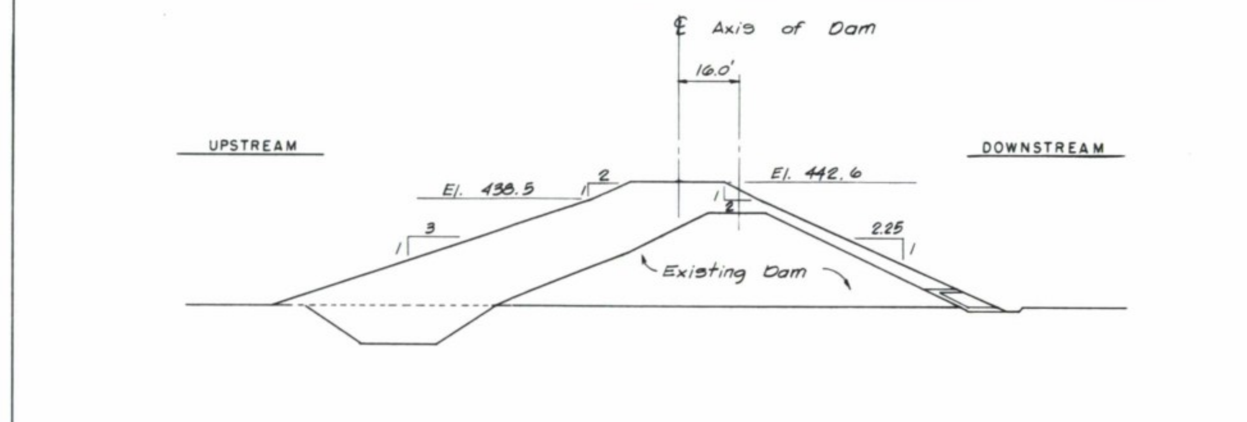

LEGEND
FEE LANDS
FEE LAND (150 ACRES)
EASEMENT LANDS
EXISTING PERMANENT POOL (64 ACRES)
S.D.F. POOL (555 ACRES)
GROSS POOL (2024 ACRES)
EXIST. VEGETATED AREA (49 ACRES)
TOTAL EASEMENT LANDS TO SDF POOL 2692 ACRES
BORROW AREA (500 ACRES)
DRY CREEK CROSSING LEVEE EASEMENT LANDS (13.3 ACRES)
S.D.F. POOL EL. 439.6
DESIGNATED BORROW AREA
GROSS POOL EL. 433.2
EXISTING RESIDUAL POOL
FEE PURCHASE LINE 50' FROM UPSTREAM TOE OF DAM (TYP.)
FEE PURCHASE LINE 50' FROM DOWNSTREAM TOE OF DAM (TYP.)
N
50'
50'
EASEMENT LANDS
NOTE:
1. Borrow area lands are included in Gross Pool lands.
2. The 2767 acre required for Spillway Design Flood storage includes 75.0 acres of Fee Lands.
REVISION DATE DESCRIPTION BY
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
DESIGNED: D. Mraz
DRAWN: G. Bucknell
CHECKED: L. Renning
SUBMITTED:
CHIEF, CIVIL DESIGN SECTION B
REDBANK AND FANCHER CREEKS, CALIFORNIA
BIG DRY CREEK
BIG DRY CREEK DAM
REAL ESTATE REQUIREMENTS & BORROW AREA
DATE APPROVED 4/22/86
SCALE AS SHOWN
SHEET B 42
50
SJ-11-20-11


Copper Ave.
℄ New Spillway
Sta. 259+10
Construction Access Road
Exit Channel
New Little Dry Creek Outlet Works
Gaging Station
Sta. 200+00
Sta. 199+50
Designated Borrow Area. Riparian vegetation to be retained.
Gross Pool El. 433.2
Leonard Ave.
Carson Ave.
Behymer Road
Dewolf Road
Existing roads to be used as access roads
Residual Pool
Cofferdam
New Big Dry Creek Outlet Works
New Exit Channel
Gaging Station
Existing Vegetation (Not included in designated borrow area.)
Sta. 150+00
Excavation limits for removal of recent alluvium
Construction Access Road
Stockpile location for topsoil (typ.)
℄ New Big Dry Creek Dam
Inspection trench
Sta. 100+00
Sta. 50+00
Sta. 35+00
Sta. 0+00
Gross Pool El. 433.2
Existing stilling basin to be removed
New stilling basin
Existing conduit to be removed and replaced
Existing control tower to be removed
New control tower
LITTLE DRY CREEK OUTLET WORKS
N.T.S.
Existing stilling basin to be removed
Existing conduit to remain in place
Plug ends of existing conduit
Existing control tower to be removed
100'
BIG DRY CREEK OUTLET WORKS
N.T.S.
Sill
Flow
SPILLWAY
SECOND PROJECT CONSTRUCTION SEASON
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
Mobilization and site preparation
Inspection trench excavation and recompaction
Little Dry Creek Outlet Works Construction
Big Dry Creek Outlet Works Construction
Cofferdam construction
Spillway construction
Big Dry Creek outlet works removal
Removal of recent alluvium
Relocations
Gaging station Construction
Drop structure repair
REVISION
DATE
DESCRIPTION
BY
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
DESIGNED: D. Mroz
DRAWN: G. Bucknell
CHECKED: L. Renning
SUBMITTED:
REDBANK AND FANCHER CREEKS, CALIFORNIA
BIG DRY CREEK
BIG DRY CREEK DAM
CONSTRUCTION PLAN AND SEQUENCE
(SECOND CONSTRUCTION SEASON)
SCALE: AS SHOWN
SHEET B43
51
SJ-11-20-11
CHIEF, CIVIL DESIGN SECTION B





EMBANKMENT SECTION WEST OF DEWOLF AVENUE



EMBANKMENT SECTION EAST OF DE WOLF AVENUE

THIRD PROJECT CONSTRUCTION SEASON

APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
Site preparation	Main Dam Construction							Demobilize
						Outlet Works Bridge and construction; Tower Access abutment	Erosion control placement	
							Permanent utilities installation	

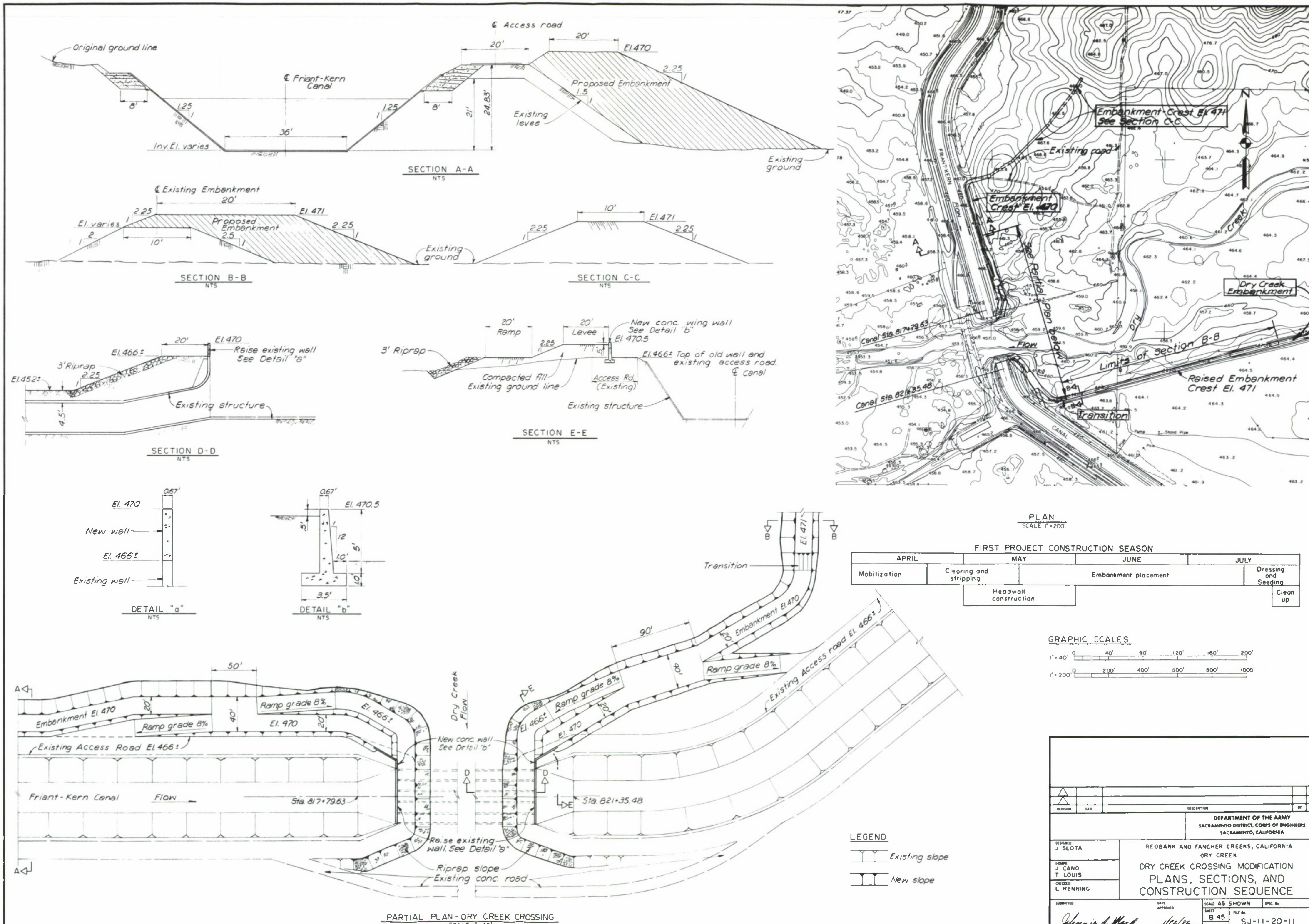
REVISION	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DESIGNED: D. Mroz
DRAWN: G. Bucknell
CHECKED: L. Renning
SUBMITTED: Johnnie A. Mack, CHIEF, CIVIL DESIGN SECTION B

REDBANK AND FANCHER CREEKS, CALIFORNIA
BIG DRY CREEK
BIG DRY CREEK DAM
CONSTRUCTION PLAN
AND SEQUENCE
(THIRD CONSTRUCTION SEASON)

DATE APPROVED: 4/22/66
SCALE: AS SHOWN
SPEC. No.
SHEET 844 52
FILE No. SJ-11-20-11



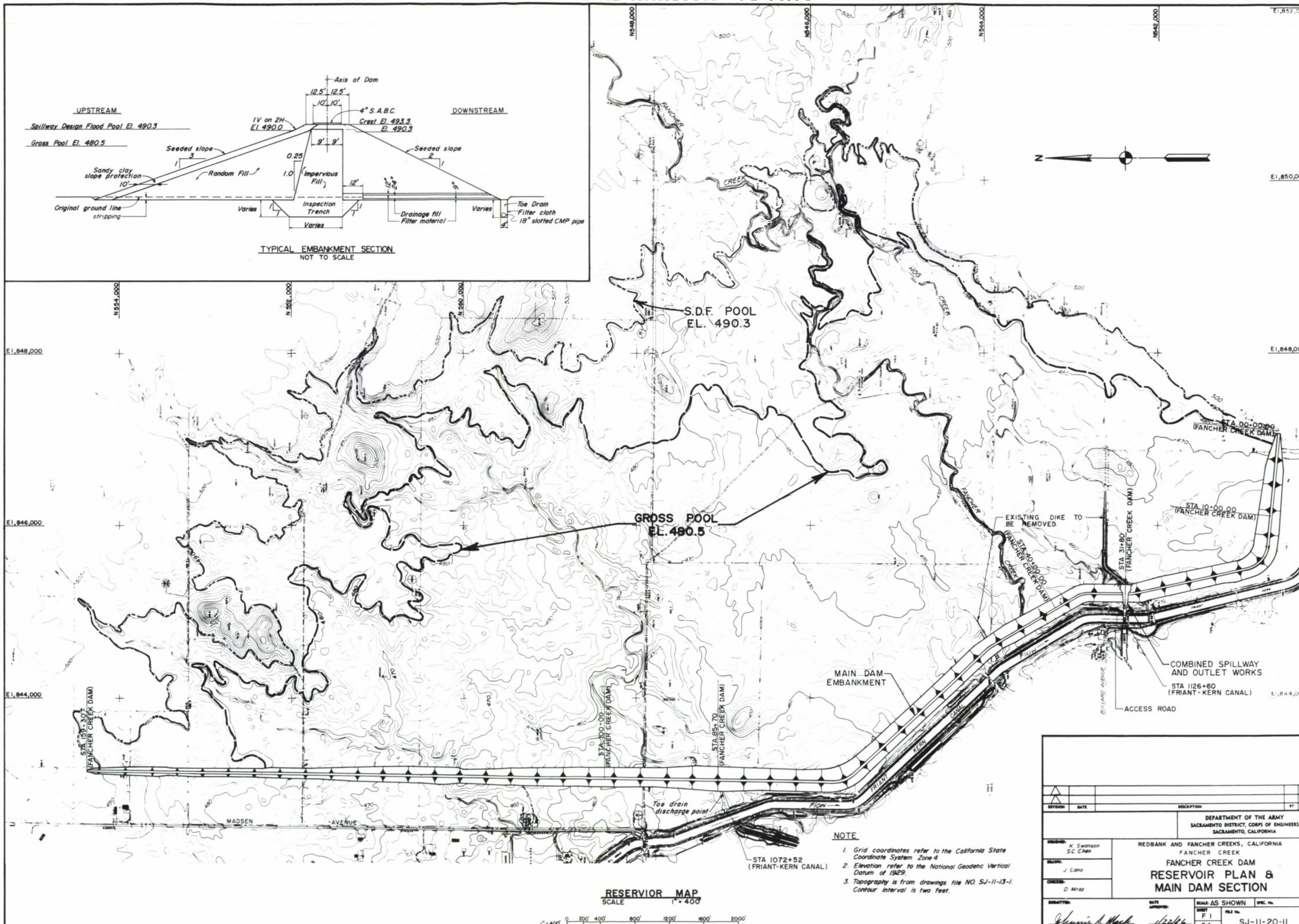
FIRST PROJECT CONSTRUCTION SEASON

APRIL	MAY	JUNE	JULY
Mobilization	Clearing and stripping	Embankment placement	Dressing and Seeding
	Headwall construction		Clean up

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

REDBANK AND FANCHER CREEKS, CALIFORNIA
DRY CREEK
DRY CREEK CROSSING MODIFICATION
PLANS, SECTIONS, AND CONSTRUCTION SEQUENCE

DESIGNED J. SLOTA
DRAWN J. CANO, T. LOUIS
CHECKED L. RENNING
SUBMITTED CHIEF, CIVIL DESIGN SECTION 6
SCALE AS SHOWN
SHEET B 45 / 53
FILE No. SJ-11-20-11



NOTE

1. Grid coordinates refer to the California State Coordinate System Zone 4
2. Elevation refer to the National Geodetic Vertical Datum of 1929.
3. Topography is from drawings file NO. SJ-11-13-1. Contour interval is two feet.

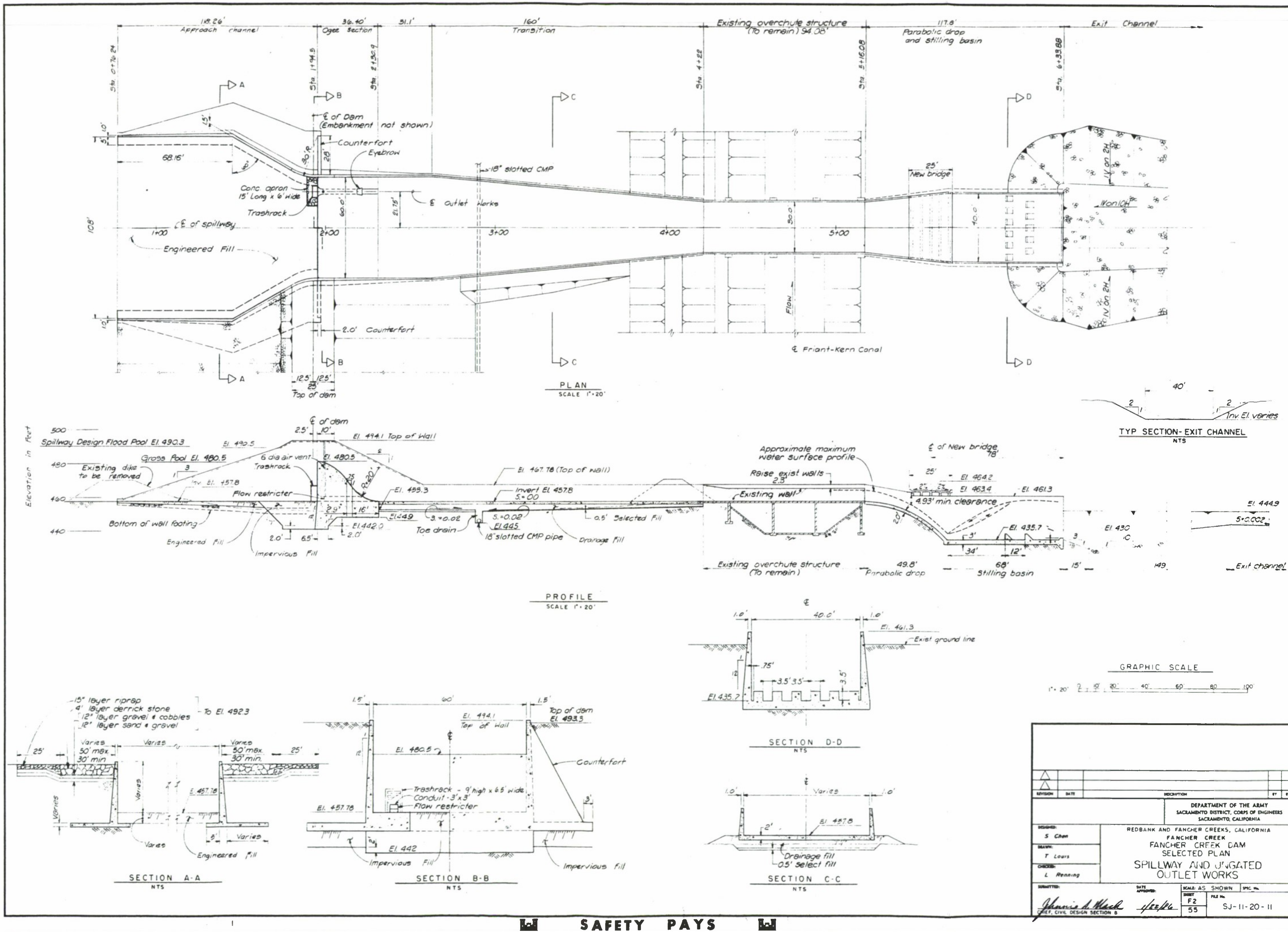
REVISION	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

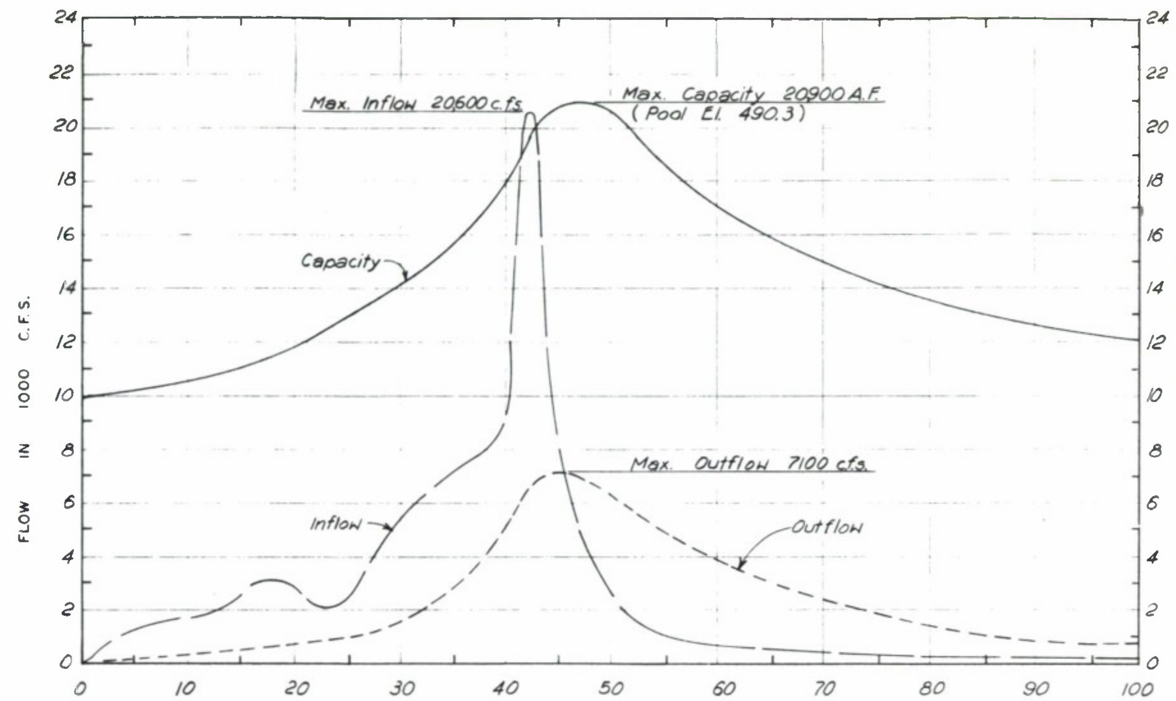
DESIGNED: K. Swanson, S.C. Chen
DRAWN: J. Cano
CHECKED: D. Mraz

REDBANK AND FANCHER CREEKS, CALIFORNIA
FANCHER CREEK
FANCHER CREEK DAM
RESERVOIR PLAN & MAIN DAM SECTION

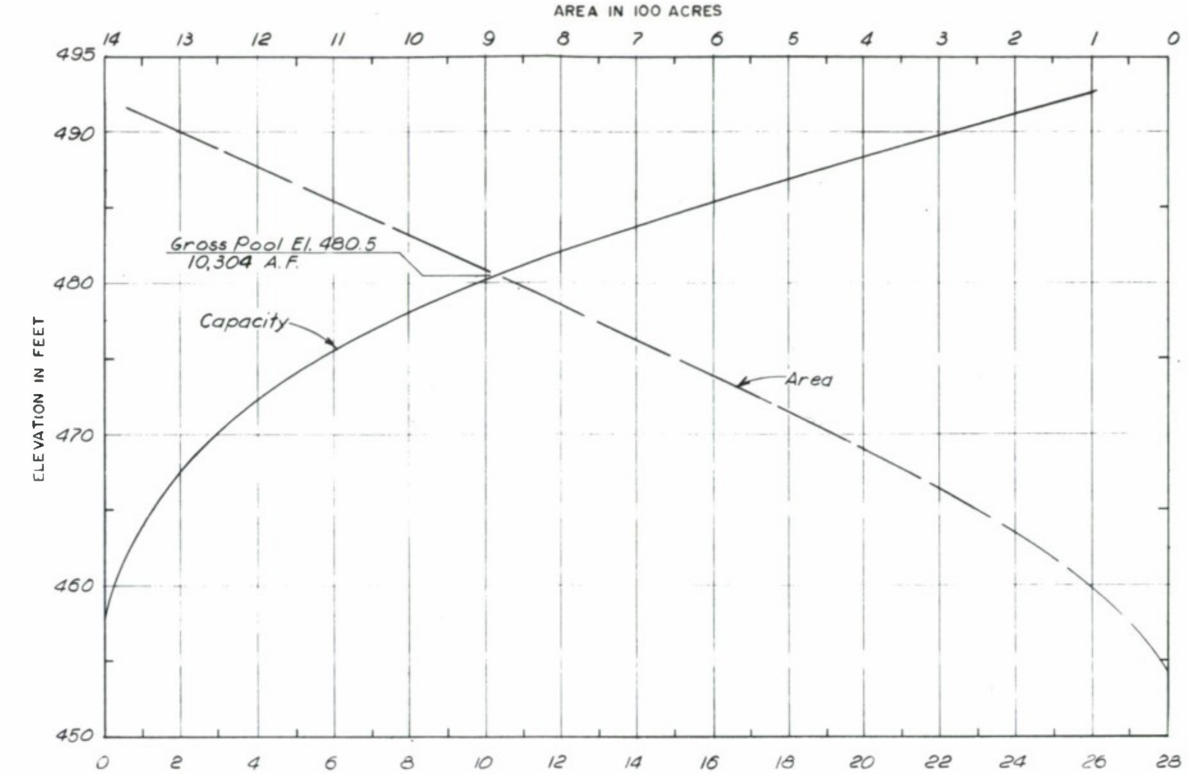
SUBMITTED: [signature] CHIEF, CIVIL DESIGN SECTION B
DATE APPROVED: 4/22/86
SCALE: AS SHOWN
SHEET F1 54
FILE No. SJ-11-20-11



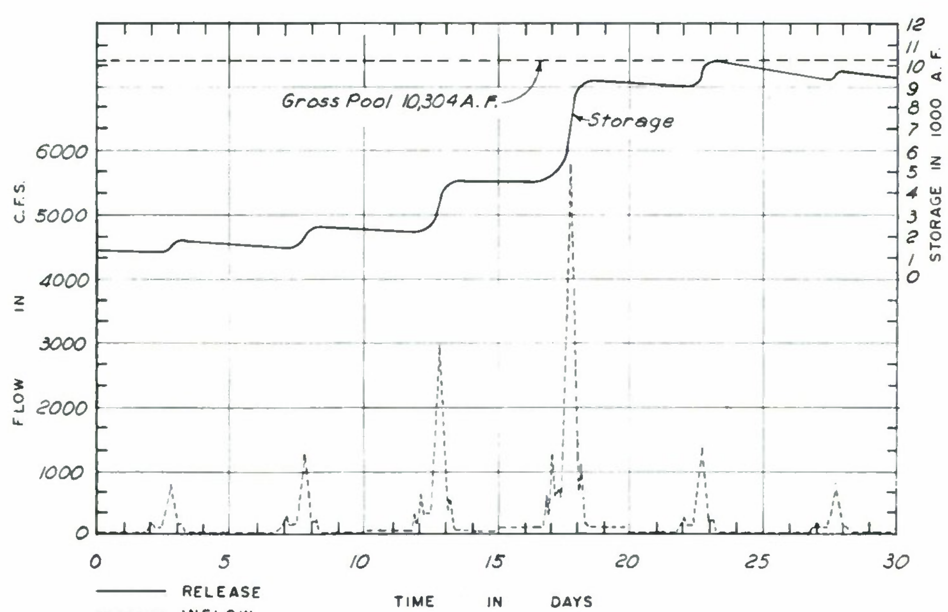
Approach channel
Ogee section
Transition
Existing overchute structure (To remain) 94.38'
Parabolic drop and stilling basin
Exit Channel
Sta 0+76.24
Sta 1+94.5
Sta 2+30.9
Sta 4+22
Sta 5+16.08
Sta 6+33.88
℄ of Dam (Embankment not shown)
Counterfort
Eyebrow
18" slotted CMP
Conc. apron 15' Long x 6' wide
Trashrack
℄ Outlet Works
℄ of spillway
Engineered Fill
2.0' Counterfort
Top of dam
25' New bridge
Flow
℄ Friant-Kern Canal
1V on 2H
1V on 10H
PLAN
SCALE 1"=20'
Elevation in Feet
Spillway Design Flood Pool El. 490.3
Gross Pool El. 480.5
Existing dike to be removed
Inv. El. 457.8
Flow restricter
6 dia air vent
Trashrack
El. 494.1 Top of Wall
℄ of dam
El. 493.3
El. 467.78 (Top of wall)
Invert El. 457.8
Bottom of wall footing
Engineered Fill
Impervious Fill
Toe drain
18" slotted CMP pipe
Drainage Fill
0.5' Selected Fill
Approximate maximum water surface profile
Raise exist walls 2.3'
Existing wall
℄ of New bridge
4.93' min. clearance
El. 461.3
El. 435.7
Stilling basin
Parabolic drop
Existing overchute structure (To remain)
Exit channel
PROFILE
SCALE 1"=20'
TYP SECTION - EXIT CHANNEL
NTS
Inv. El. varies
15" layer riprap
4' layer derrick stone
12" layer gravel & cobbles
12" layer sand & gravel
To El. 492.3
Varies
50' max. 30' min.
Engineered Fill
SECTION A-A
NTS
Top of dam El. 493.5
El. 494.1 Top of Wall
El. 480.5
Trashrack - 9' high x 6.5' wide
Conduit - 3'x3'
Flow restricter
El. 457.78
El. 442
Impervious Fill
Counterfort
SECTION B-B
NTS
El. 461.3
Exist ground line
El. 435.7
SECTION D-D
NTS
El. 457.8
Drainage fill
0.5' select fill
SECTION C-C
NTS
GRAPHIC SCALE
1"=20'
SAFETY PAYS
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
REDBANK AND FANCHER CREEKS, CALIFORNIA
FANCHER CREEK
FANCHER CREEK DAM
SELECTED PLAN
SPILLWAY AND UNGATED
OUTLET WORKS
DESIGNED: S Chen
DRAWN: T Louis
CHECKED: L Renning
CHIEF, CIVIL DESIGN SECTION B
SCALE: AS SHOWN
SHEET F2 55
SJ-11-20-11



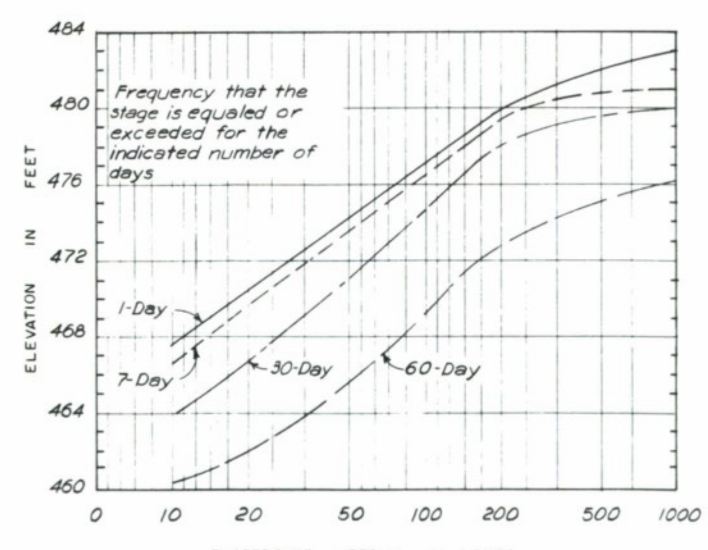
SPILLWAY DESIGN FLOOD (PMF) ROUTING CURVE



AREA/CAPACITY CURVE



RESERVOIR DESIGN FLOOD (200-YEAR) ROUTING CURVE



STAGE FREQUENCY CURVE

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

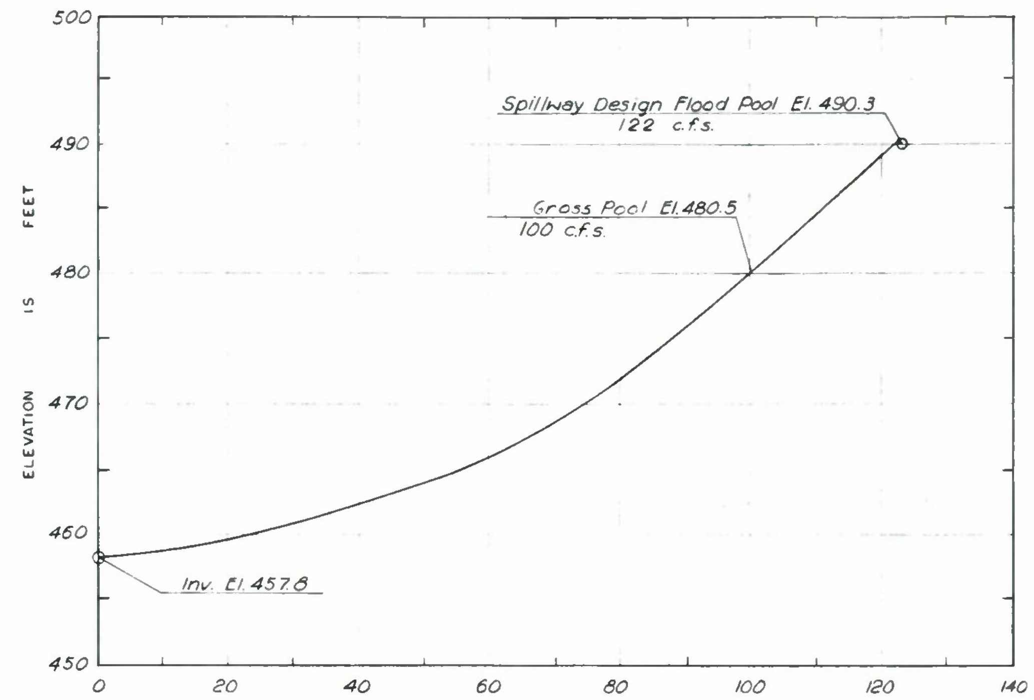
DESIGNED: S.C. Chen, C. Mitkovic, J. Lahaye
DRAWN: J. Cano
CHECKED: L. Renning, B. O'Leary, H. Madehom

REDBANK AND FANCHER CREEKS, CALIFORNIA
FANCHER CREEK

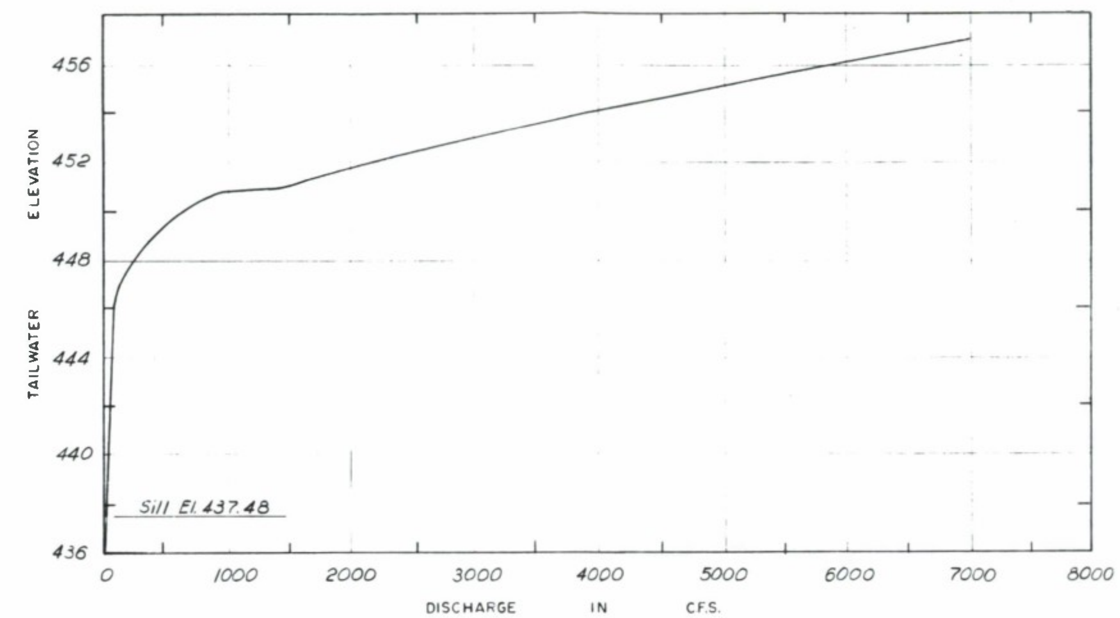
FANCHER CREEK DAM

HYDRAULIC DATA

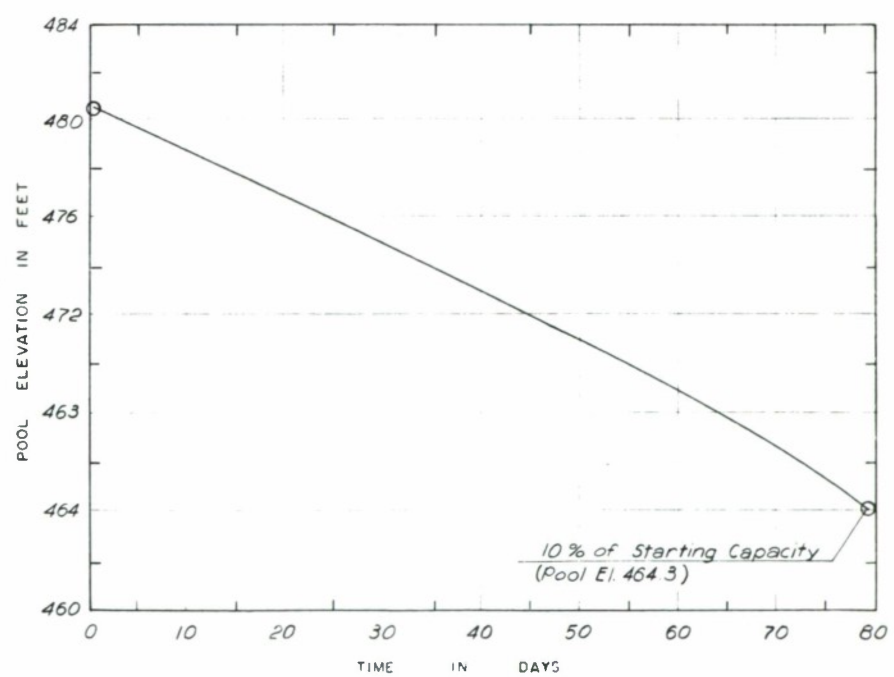
SUBMITTED: Harold C. Huff
CHIEF, HYDRAULIC DESIGN SECTION
DATE APPROVED: 22 JAN 86
SCALE: AS SHOWN
SHEET F3 56
FILE No. SJ-11-20-11



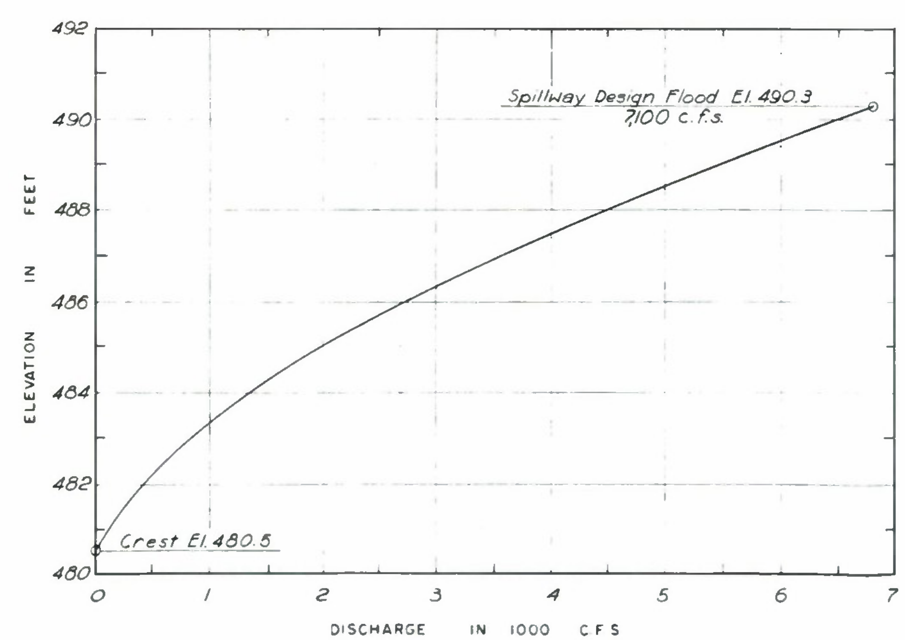
OUTLET WORKS DISCHARGE RATING CURVE



OUTLET WORKS TAILWATER RATING CURVE

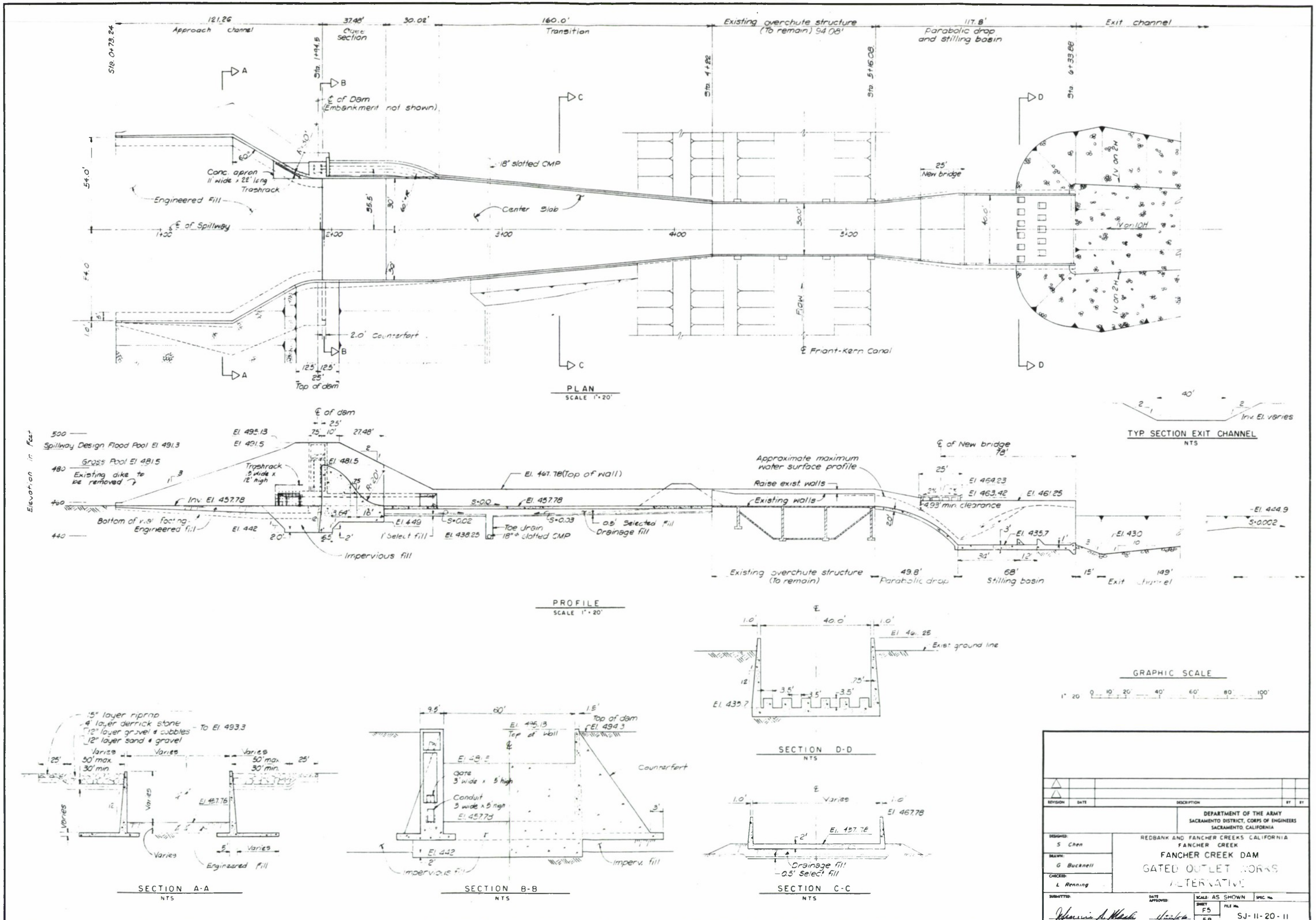


RESERVOIR DRAWDOWN CURVE

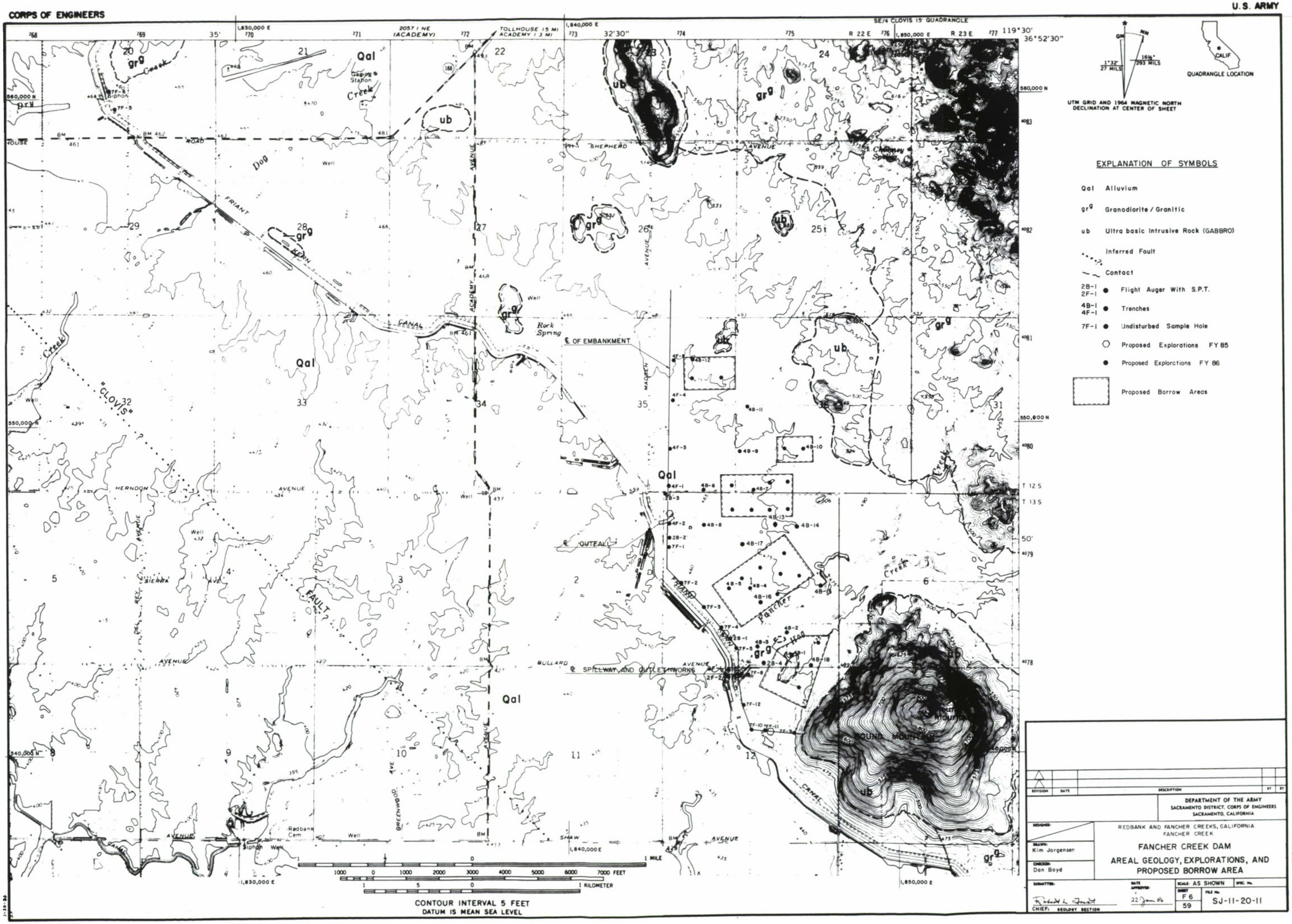


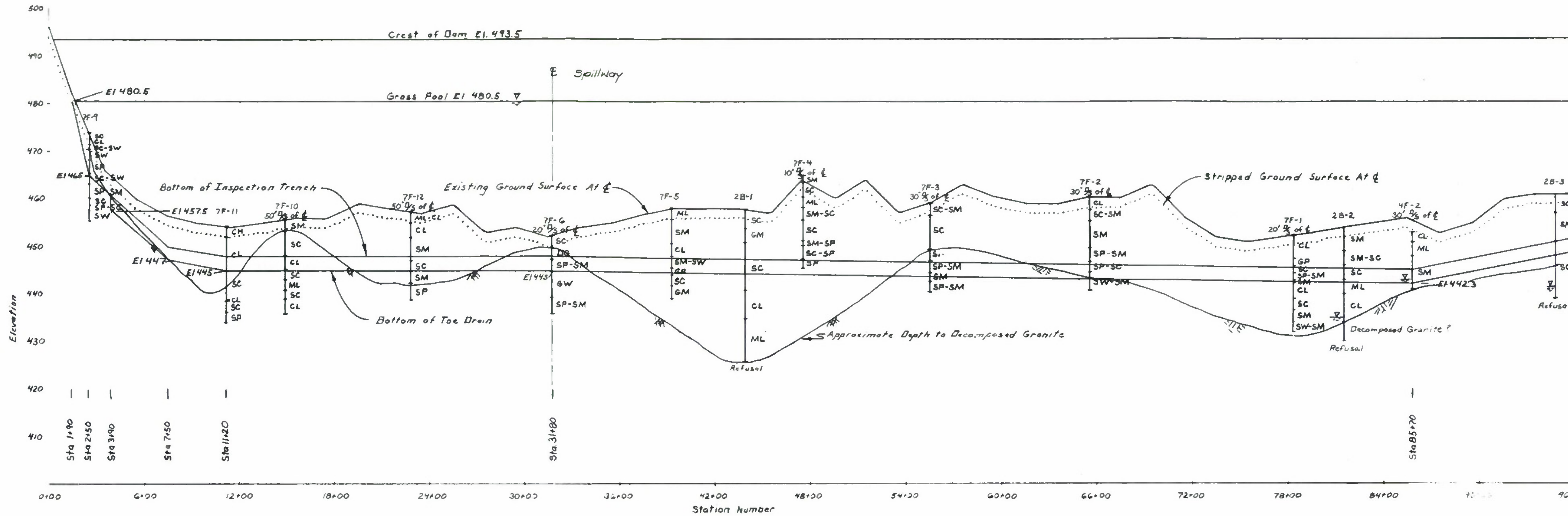
SPILLWAY DISCHARGE RATING CURVE

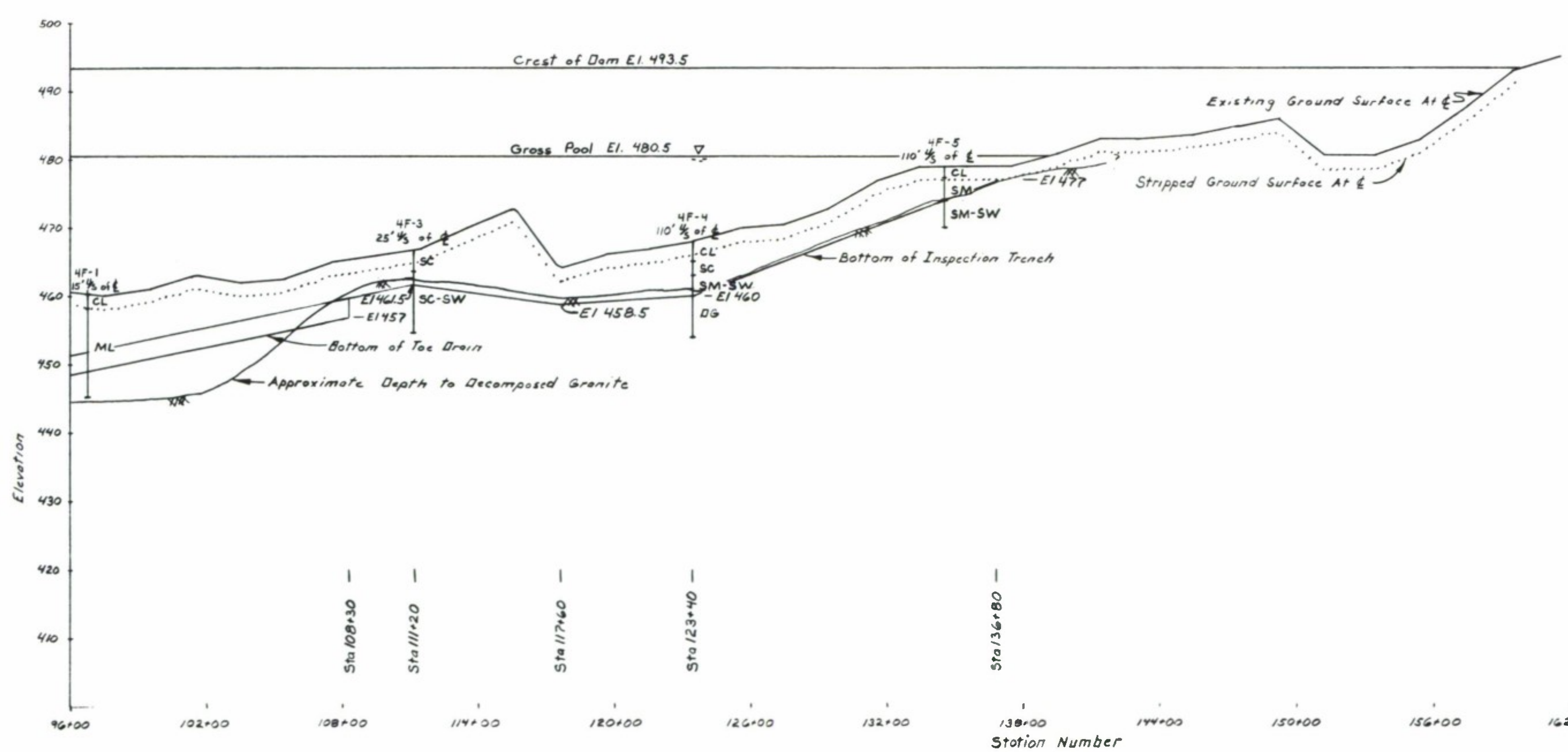
DIVISION / DATE / DESCRIPTION / BY	
	DEPARTMENT OF THE ARMY SACRAMENTO DISTRICT, CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA
DESIGNED: C. Mitrovic	REDBANK AND FANCHER CREEKS, CALIFORNIA FANCHER CREEK
DRAWN: J. Cano	FANCHER CREEK DAM
CHECKED: B. OLeary	HYDRAULIC DATA
SUBMITTED: Harold C. Huff, CHIEF, HYDRAULIC DESIGN SECTION	DATE APPROVED: 22 JAN 86 / SCALE: AS SHOWN / SHEET F4 57 / FILE No. SJ-11-20-11



PLAN
SCALE 1"=20'
PROFILE
SCALE 1"=20'
TYP SECTION EXIT CHANNEL
NTS
SECTION A-A
NTS
SECTION B-B
NTS
SECTION C-C
NTS
SECTION D-D
NTS
GRAPHIC SCALE
Approach channel
Ogee Section
Transition
Existing overchute structure (To remain) 94.08'
Parabolic drop and stilling basin
Exit channel
Center Slab
18" slotted CMP
Engineered Fill
℄ of Spillway
℄ of Dam (Embankment not shown)
Conc. apron 11' wide x 22' long
Trashrack
2.0' Counterfort
Top of dam
25' New bridge
℄ Friant-Kern Canal
Flow
Spillway Design Flood Pool El 491.3
Gross Pool El 481.5
Existing dike to be removed
Bottom of wall footing
Engineered fill
Impervious fill
El. 467.78 (Top of wall)
Approximate maximum water surface profile
Raise exist. walls
Existing walls
℄ of New bridge
4.93' min. clearance
Toe drain 18" slotted CMP
0.5' Selected fill
Drainage fill
Existing overchute structure (To remain)
Parabolic drop
Stilling basin
Exit channel
15" layer riprap
4' layer derrick stone
12" layer gravel & cobbles
12" layer sand & gravel
To El 493.3
Gate 3' wide x 5' high
Conduit 3' wide x 5' high
Counterfort
Imperv. fill
Exist. ground line
Drainage fill
0.5' Select fill
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
REDBANK AND FANCHER CREEKS CALIFORNIA
FANCHER CREEK
FANCHER CREEK DAM
GATED OUTLET WORKS
ALTERNATIVE
DESIGNED: S. Chen
DRAWN: G. Bucknell
CHECKED: L. Renning
CHIEF, CIVIL DESIGN SECTION B
SCALE: AS SHOWN
SHEET F5 58
SJ-11-20-11


CORPS OF ENGINEERS
U.S. ARMY
SE/4 CLOVIS 15' QUADRANGLE
TOLLHOUSE 15 MI
ACADEMY 1.3 MI
2057 I NE (ACADEMY)
UTM GRID AND 1964 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET
QUADRANGLE LOCATION
CALIF
EXPLANATION OF SYMBOLS
Qal Alluvium
gr^g Granodiorite / Granitic
ub Ultra basic Intrusive Rock (GABBRO)
Inferred Fault
Contact
2B-1 2F-1 Flight Auger With S.P.T.
4B-1 4F-1 Trenches
7F-1 Undisturbed Sample Hole
Proposed Explorations FY 85
Proposed Explorations FY 86
Proposed Borrow Areas
℄ OF EMBANKMENT
OUTFALL
SPILLWAY AND OUTLET WORKS
ROUND MOUNTAIN
FRIANT KERN CANAL
Fancher Creek
Dog Creek
Rock Spring
"CLOVIS" FAULT
SHEPHERD AVENUE
HERNDON AVENUE
SIERRA AVE
BULLARD AVENUE
SHAW AVENUE
ACADEMY AVENUE
MADSEN AVENUE
GREENWOOD AVE
DEL REY AVENUE
Redbank Cem
CONTOUR INTERVAL 5 FEET
DATUM IS MEAN SEA LEVEL
1 MILE
7000 FEET
1 KILOMETER
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
REDBANK AND FANCHER CREEKS, CALIFORNIA
FANCHER CREEK
FANCHER CREEK DAM
AREAL GEOLOGY, EXPLORATIONS, AND
PROPOSED BORROW AREA
DRAWN: Kim Jorgensen
CHECKED: Don Boyd
CHIEF: GEOLOGY SECTION
DATE APPROVED: 22 Jan 86
SCALE: AS SHOWN
SHEET F 6 59
FILE No. SJ-11-20-11





NOTES:

1. Classifications are in accordance with the Unified Soils Classification System (ASTM D-2487) except for Decomposed Granite (DG)
2. For complete Logs of Explorations in the Fancher Creek Area, See Sheet Nos. F8-F15.
3. For locations of Explorations, see Sheet No. F6.
4. Depth of stripping is 2-feet below existing ground surface.
5. Depth of inspection trench is 3-feet above bottom of Toe Drain.
6. At station 85+70, an outfall pipe will be jacked under the Kern-Friant canal.
7. Profile looking downstream

LEGEND:

▽ Depth of groundwater

DG Decomposed Granite

REVISION	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DESIGNED: K. Swanson
DRAWN: K. Swanson
CHECKED: D. Anderson

REDBANK AND FANCHER CREEKS, CALIFORNIA
FANCHER CREEK
FANCHER CREEK DAM
SOIL PROFILE

SUBMITTED:
CHIEF, SOILS DESIGN SECTION

DATE APPROVED:
SCALE:
SHEET F7 / 60
FILE No. SJ-11-20-11
SPEC. No.

2B-1

Depth	Class	GR	SA	FI	LL	PI	MC	Description
0	SC	-	-	-	-	-	-	*CLAYEY SAND, yellowish-red, damp, est. 79% graded angular to subangular grained sand, est. 14% medium plasticity fines, est. 6% fine gravel to 3/8" maximum, non- to slightly cemented, micaceous
4.0'	GM	45	39	16	31	8	7	SILTY SANDY GRAVEL, light brown, gravel to 1-1/2" maximum, graded sand, some fragments of moderately cemented material
7.0'		-	-	-	-	-	-	*CLAYEY SAND, reddish-brown, damp, est. 60% graded sand, est. 32% medium plasticity fines, est. 6% gravel to 1" maximum, micaceous
12.0'	SC	-	55	45	-	-	23	CLAYEY SAND, dark yellowish-brown, very fine to medium grained sand, medium plasticity fines, micaceous
17.0'	CL	-	-	-	-	-	-	*SANDY CLAY, reddish-brown, moist, est. 55% medium plasticity fines, est. 45% fine grained sand, trace of gravel to 1" maximum
23.0'	(ML)	-	-	-	-	-	-	SANDY SILT, dark yellowish-brown, saturated
32.0'								Refusal

2B-2

Depth	Class	GR	SA	FI	LL	PI	MC	Description
0	SM	10	50	40	-	-	17	SILTY SAND, medium to dark yellowish-brown, very fine to medium grained sand, low plasticity fines, gravel to 3/4" maximum
5.0'	SM-SC	6	65	29	25	5	10	SILTY CLAYEY SAND, dark yellowish-brown, very fine to medium subrounded grained sand, gravel to 1" maximum, micaceous
8.0'	SC	-	-	-	-	-	-	*CLAYEY SAND, reddish-brown, moist, est. 80% graded angular to subangular grained sand, est. 11% low plasticity fines, est. 9% rounded to subrounded gravel to 3/4" maximum
11.0'	ML	-	34	66	-	-	20	SANDY SILT, mottled dark to medium yellowish-brown, low to medium plasticity fines, very fine to medium grained sand
14.0'	CL	-	-	-	-	-	-	*SANDY CLAY, reddish-brown, moist, est. 55% medium plasticity fines, est. 45% fine grained sand, traces of fine gravel to 3/4" maximum, micaceous
19.0' ▽								
20.0'	SC	-	-	-	-	-	-	*CLAYEY SAND, reddish-brown, moist, est. 55% graded sand, est. 39% medium plasticity fines, est. 6% gravel to 1" maximum
24.0'								Refusal

Sept 1983

2B-3

Depth	Class	GR	SA	FI	LL	PI	MC	Description
0	SC	13	49	36	37	20	12	CLAYEY SAND, pale yellowish-brown, graded sand, gravel to 1" maximum
4.0'	SM	14	53	33	-	-	12	SILTY SAND, medium to light brown, graded sand, low to medium plasticity fines, gravel to 1-1/2" maximum
5.0'	SM	-	-	-	-	-	-	*SILTY SAND, yellowish-brown, damp, est. 90% graded angular grained sand, est. 10% non-plastic fines, micaceous (Decomposed Granite)
10.0'		2	80	16	36	12	9	CLAYEY SAND, pale to medium yellow-brown, graded angular grained sand, gravel to 3/4" maximum, micaceous (Decomposed Granite)
15.0'	SC	-	-	-	-	-	-	*CLAYEY SAND, olive brown, moist, est. 75% graded angular to subangular grained sand, est. 25% medium plasticity fines, highly micaceous (Decomposed Granite)
19.5' ▽								
22.0'								

Sept 1983

2B-4

Depth	Class	N	GR	SA	FI	LL	PI	MC	Description
0	SC	2	-	-	-	-	-	-	CLAYEY SAND, dark brown, damp, est. 60-70% very fine grained sand, est. 30-40% fines
4.0'	SM	6	-	68	34	-	-	-	SILTY SAND, brown, wet, very fine to medium grained sand, medium plasticity fines, non-cemented
5.5'	(ML)	77	-	-	-	-	-	-	SANDY SILT, light olive-green with light tan streaks, dry to damp, est. 70-80% high plasticity fines, 20-30% very fine grained sand, slightly cemented
8.0'	(SM)	78	-	-	-	-	-	-	SILTY SAND, olive-green to brown, damp, est. 70% very fine to coarse granitic sand, est. 20% medium plasticity fines, est. 10% subrounded gravel to 3/4" maximum, slightly cemented
9.0'	SC	20	-	61	39	34	17	-	CLAYEY SAND, olive-green, damp, very fine to medium grained sand
11.5'	(SC)	61	-	-	-	-	-	-	CLAYEY SAND, olive-green to brown, damp, 80-90% very fine to coarse grained sand, fines vary from silt to clay, scattered fine gravel
13.0'	(SM)	R, 57	-	-	-	-	-	-	SILTY SAND, tannish-grey, wet, est. 80-90% very fine to medium grained sand, est. 10-20% low plasticity fines. At 15.5' DECOMPOSED GRANITE, light tannish-grey, wet
19.5'									

VERTICAL SCALE: 1" = 2'

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			GROUP SYMBOLS	TYPICAL NAMES
COARSE GRAINED SOILS 50% or more retained on the No. 200 sieve.	GRAVELS More than half of coarse fraction retained on the No. 4 sieve.	Clean gravels	GW	Well-graded gravels, gravel-sand mixtures, little or no fines.
			GP	Poorly-graded gravels, gravel-sand mixtures, little or no fines.
		Gravels with fines	GM	Silty gravels, gravel-sand mixtures.
			GC	Clayey gravels, gravel-sand-clay mixtures.
	SANDS More than half of coarse fraction passing the No. 4 sieve.	Clean sands	SW	Well-graded sands, gravelly sands, little or no fines.
			SP	Poorly-graded sands, gravelly sands, little or no fines.
		Sands with fines	SM	Silty sands, sand-silt mixtures.
			SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS More than 50% passing the No. 200 sieve.	SILTS AND CLAYS	Liquid Limit below 50%	ML	Inorganic silts and very fine sands, rock flour, silty fine sands or silts. Plasticity below "A" line.
			CL	Inorganic clays, gravelly clays, sandy clays, lean clays. Plasticity above "A" line.
			OL	Organic silts and organic clays. Plasticity below "A" line.
		Liquid Limit 50% and above	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts. Plasticity below "A" line.
			CH	Inorganic fat clays. Plasticity above "A" line.
			OH	Organic clays or organic silts. Plasticity below "A" line.
Highly organic soils			Pt	Peat, organic content greater than 60%.

LEGEND:

- ▽ Groundwater Level.
- GR Gravel, percent by weight passing 3-inch sieve and retained on the No. 4 sieve.
- SA Sands, percent by weight passing the No. 4 sieve and retained on the No. 200 sieve.
- FI Fines, percent by weight passing the No. 200 sieve.
- LL Liquid Limit.
- PI Plasticity Index (Liquid Limit Minus Plastic Limit).
- MC Field Moisture Content in Percent of Dry Weight.
- (SC) Visual Field Classification.
- * Laboratory Visual Classification.

NOTES:

1. Classifications are in accordance with the Unified Soils Classification System (ASTM D-2487).
2. All sieve sizes on the chart are U.S. Standard.
3. The terms "silt" and "clay" are used respectively to distinguish materials exhibiting lower plasticity from those with higher plasticity. The minus No. 200 sieve material is silt if the liquid limit and plasticity index plot below the "A" line on the plasticity chart (ASTM D-2487) and is clay if the liquid limit and plasticity index plot above the "A" line on the chart.
4. Borderline Classification: Soils possessing characteristics of two groups are designated by combinations of group symbols. For example GW-GC, a well-graded gravel-sand mixture with a clay binder.
5. Borings 2B-1 through 2B-3 were drilled with a Mobile B-80 drill rig equipped with a 6-1/2-inch hollow stem auger on 31 August and 1 September 1983.
6. For additional logs of borings and trenches in the Fancher Creek Dam Site area, see sheet Nos. F9-F15.
7. For location of borings, see sheet No. F6.
8. Groundwater was encountered during drilling.
9. Though designated as borrow explorations, 2B-1 thru 2B-3 were drilled along the dam centerline. Therefore, all materials encountered represent foundation conditions.

GRAPHIC SCALE

1" = 2' — 0, 1', 2', 4', 6', 8', 10'

NOTES CONT'D:

10. Boring 2B-4 was drilled with a 6-inch hollow stem auger on 31 July 1984.
11. Refusal of the Standard Penetrometer is as one of the following:
    a. 25 blows for 1" or less advancement of sampler; or
    b. 50 blows for 1" to 6" advancement of sampler.

REVISION	DATE	DESCRIPTION	BY	BY
△				
△				

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DESIGNED: K. SWANSON
DRAWN: N. WAHL/J. HAYES
CHECKED: D. ANDERSON

REDBANK AND FANCHER CREEKS, CALIFORNIA
FANCHER CREEK

FANCHER CREEK DAM
LOGS OF EXPLORATIONS
2B-1 thru 2B-4

SUBMITTED: Clark E. Stange — CHIEF, SOILS DESIGN SECTION
DATE APPROVED: 4/22/86
SCALE:
SPEC No.
SHEET F 8 / 61
FILE No. SJ-11-20-11

ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING

2 F - 1

Depth	Class	N	GR	SA	FI	LL	PI	MC	Description
0 – 4.0'	SC	15	21	59	20	32	12	-	CLAYEY SAND, light brown, damp, well graded sand, gravel to 1" size, non-cemented (Fill Material)
4.0' – 10.5'	ML	13, 10, 3	-	34	68	22	1	-	SANDY SILT, light to dark brown, dry to damp, very fine to medium grained sand, non-cemented
10.5' – 12.6'	ML-CL	7, 6	-	49	51	24	5	-	SANDY CLAY, dark brown, moist, very fine to medium grained sand, non-cemented
12.6' – 13.6'	(SC)		-	-	-	-	-	-	CLAYEY SAND, greenish-brown, wet, est. 70-80% very fine grained sand, est. 20-30% fines, non-cemented
13.6' – 15.5'	(SM)	16	-	-	-	-	-	-	SILTY SAND, brownish grey, est. 90% very fine to fine grained sand, est. 10% non to low plasticity fines, non-cemented
15.5' – 21.0'	SM	12, 19, 35	11	75	14	-	-	-	SILTY SAND, grey, saturated, very fine to coarse angular grained sand, gravel to 1" size, non-cemented
21.0'									At 21.0' depth, Decomposed Granite

Vertical Scale 1" = 2'

2 F - 2

Depth	Class	N	Description
0 – 7.0'	(SM)	26, 22, 4	SILTY SAND, light greyish-brown, damp, est. 70-80% very fine to coarse grained sand, est. 20-30% non to low plasticity fines, traces of fine gravel, non-cemented
7.0' – 9.1'	(SM)	8	SILTY SAND, brown to dark brown, damp to moist, est 85-75% very fine to medium grained sand, est. 25-35% medium plasticity sand, non-cemented
9.1' – 11.2'	(ML)	19	SANDY SILT, dark brown, moist, est. 70 to 80% medium plasticity fines, est. 20-30% very fine to fine grained sand, non-cemented
11.2' – 17.5'	(ML)	4, 3, 3	SANDY SILT, brownish-black, wet, est. 60-70% medium plasticity fines, est. 30 to 40% very fine grained sand, highly organic, non-cemented, (original creek-bed) At 13.5' depth, wet to saturated At 16.0' depth, greenish-brown, no organics
17.5' – 21.5'	(SM)	5, 6	SILTY SAND, brown to greyish-brown, wet, est. 70-80% very fine to medium grained sand, est. 20-30% low to medium plasticity fines, non-cemented, scattered gravel fragments to 1/2" size
21.5' – 22.6'	(SW)	27	SAND, multi-colored, saturated, fine to coarse angular to sub-angular grained sand, non- cemented, thin layers of fines 0.2' thick
22.6' – 23.0'	(SM)		SILTY SAND, brownish-grey, wet, est. 60-70% very fine to coarse grained sand, est. 30-40% low to medium plasticity fines

NOTES

1. For location of borings, see Sheet No. F6
2. For additional notes and legend, see Sheet No. F8
3. For additional logs of borings in the Fancher Creek Dam Site area, see Sheet No. F8-F15.
4. Boring 2B-4 was drilled with a 6-inch hollow stem auger on 31 July 1964.

GRAPHIC SCALE

1" = 2'   0 1' 2' 4' 6' 8' 10'

STANDARD PENETROMETER DESCRIPTIVE DATA

COHESIONLESS		COHESIVE	
Blows*	Relative Density	Blows*	Consistency
0-4	Very Loose	0-1	Very Soft
5-10	Loose	2-4	Soft
11-20	Firm	5-8	Firm
21-30	Very Firm	9-15	Stiff
31-50	Dense	16-30	Very Stiff
51+	Very Dense	31+	Hard

*Blows per 1.0 ft. of penetration of a 2-inch O.D. and 1-3/8 inch I.D. sampler driven by a 140-lb. hammer, 30-inch freefall.

REVISION	DATE	DESCRIPTION	BY	BY

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DESIGNED: K. Swanson
DRAWN: K. Wahl
CHECKED: D. Anderson

REDBANK AND FANCHER CREEKS, CALIFORNIA
FANCHER CREEK
FANCHER CREEK DAM
LOGS OF EXPLORATIONS
2F-1 and 2F-2

SUBMITTED: CHIEF, SOILS DESIGN SECTION
DATE APPROVED:
SCALE:
SPEC. No.
SHEET F 9 / 62
FILE No. SJ-11-20-11

7 F - 1

Depth		CB	GR	SA	FI	LL	PI	MC	Description
0 – 2.5'	CL	-	-	44	56	26	14	-	SANDY CLAY, reddish-brown, very fine to medium subangular to angular grained sand, slightly organic, very stiff to hard consistency, non-cemented. $G_s = 2.73$
2.5' – 5.0'	(CL)	-	-	-	-	-	-	-	SANDY CLAY, as above
5.0' – 6.5'	GP	22	60	13	5	-	-	2	SANDY GRAVEL with COBBLES, light brown, cobbles to 5" maximum, fine to coarse gravel to 3" maximum
6.5' – 8.0'	SC	-	-	-	-	-	-	-	*CLAYEY GRAVELLY SAND, reddish-brown, damp, estimated 80% graded sand, estimated 25% hard angular to subrounded gravel to 2-1/2" maximum, estimated 15% medium plasticity fines, mica flakes
8.0' – 9.5'	SP-SM	-	-	89	11	-	-	-	SILTY SAND, light brown, damp, very fine to coarse grained sand
9.5' – 10.0'	SM	-	2	61	17	45	16	11	SILTY SAND, as above except gravel to 3/8" maximum, $\gamma_d = 119.0$ PCF
10.0' – 13.3'	CL	-	-	30	70	-	-	18	SANDY CLAY, reddish-brown to tan, medium plasticity fines, very fine to medium grained sand, stiff to very stiff consistency, non-cemented, $G_s = 2.78$
13.3' – 15.8'	SC	-	15	69	16	33	9	-	GRAVELLY CLAYEY SAND, reddish-brown to tan, very fine to coarse grained sand, gravel to 3/4" maximum
15.8' – 18.3'	SM	-	-	-	-	-	-	-	*SILTY SAND, grey-brown, damp, estimated 75-80% fine grained sand, estimated 20-25% medium plasticity fines, medium density, mica flakes
18.3' – 20.0'	SW-SM	-	17	71	12	-	-	-	SILTY GRAVELLY SAND, light brown with slight iron oxide staining, very fine to coarse grained sand, gravel to 1-1/2" maximum, non-plastic fines, firm density, non-cemented
20.0' – 20.5'	(SW-SM)	-	-	-	-	-	-	-	SILTY GRAVELLY SAND, light brown, est. 80-70% fine to coarse subangular grained sand, est. 25-30% subrounded gravel, est. 5-10% non-plastic fines, firm, non-cemented

7 F - 2

Depth		GR	SA	FI	LL	PI	MC	Description
0 – 2.6'	(CL)	-	-	-	-	-	16	SANDY CLAY, brown, estimated 70-80% medium plasticity fines, estimated 20-30% fine angular grained sand, slightly organic, very stiff to hard consistency, non-cemented. $\gamma_d = 111.9$ PCF
2.6' – 5.0'	SC-SM	-	51	46	27	7	-	SILTY CLAYEY SAND, reddish-brown, damp, very fine to medium grained sand, $G_s = 2.79$
5.0' – 8.0'	SM	1	71	28	-	-	15	SILTY SAND, reddish-brown with iron oxide staining, very fine to fine grained sand, non-plastic fines, dense density, non-cemented, $\gamma_d = 113.4$ PCF
8.0' – 10.7'	(SM)	-	-	-	-	-	-	SILTY SAND, as above
10.7' – 13.4'	SP-SM	3	90	7	-	-	-	SILTY SAND, light brownish-grey, damp, very fine to coarse grained sand, non-plastic fines, gravel to 1/2" maximum, dense
13.4' – 15.7'	SP-SC	-	61	9	45	27	22	CLAYEY SAND, light brownish-grey, very fine to medium grained sand, $\gamma_d = 101.1$ PCF
15.7' – 18.2'	SW-SM	1	94	5	-	-	9	SILTY SAND, light brownish-grey, very fine to coarse grained sand, gravel to 3/8" maximum
18.2' – 19.7'		1	94	5	-	-	8	SILTY SAND, light grey, very fine to coarse grained sand, gravel to 3/8" maximum, (Decomposed Granite). $\gamma_d = 134.1$ PCF

7 F - 3

Depth		GR	SA	FI	LL	PI	MC	Description
0 – 2.6'	SC-SM	-	61	36	24	7	-	SILTY CLAYEY SAND, reddish-brown, dry to damp, very fine to medium angular grained sand, slightly organic, very stiff to hard, non-cemented, shrinkage limit = 15%
2.6' – 5.0'		-	87	33	58	19	6	CLAYEY SAND, brown, very fine to medium subangular to angular grained sand, very firm density, non-cemented
5.0' – 7.0'	SC	-	-	-	-	-	-	*CLAYEY SAND, reddish-brown, damp, estimated 75-80% medium grained sand, estimated 20-25% medium plasticity fines, low density, mica flakes
7.0' – 9.7'		-	87	13	38	15	-	CLAYEY SAND, reddish-brown with iron oxide staining, damp, very fine to coarse subangular to angular grained sand, dense to very dense, non-cemented
9.7' – 12.0'	(SP)	-	-	-	-	-	-	SAND, light grey and black, damp, fine to coarse grained sand, gravel to 1/4" maximum, highly weathered, (Decomposed Granite)
12.0' – 14.8'	SP-SM	-	-	-	-	-	-	*SILTY SAND, light grey-brown, damp, estimated 95% medium to very coarse grained sand, estimated 5% low plasticity fines, medium density, weathered mica flakes, weathered feldspars, (Decomposed Granite)
14.8' – 18.5'	SM	1	84	15	38	9	9	SILTY SAND, light grey and black, very fine to coarse grained sand, gravel to 3/8" maximum, highly weathered, (Decomposed Granite), $\gamma_d = 122.8$ PCF
18.5' – 18.8'	SP-SM	-	-	-	-	-	9	*SILTY SAND, light grey-brown, estimated 95% medium to very coarse grained sand, estimated 5% low plasticity fines, medium density, weathered mica flakes, weathered feldspars, (Decomposed Granite)

7 F - 4

Depth		CB	GR	SA	FI	LL	PI	MC	Description
0 – 1.8'	SM	-	-	57	43	13	2	-	SILTY SAND, brown, dry to damp, very fine to medium subangular to angular grained sand, slightly organic, stiff to very stiff, non-cemented
1.8' – 4.4'	SC	-	-	-	-	-	-	-	*CLAYEY SAND, reddish-brown, damp, estimated 75-80% medium grained sand, estimated 20-25% medium plasticity fines, traces of hard subangular gravel to 3/4" maximum, medium density, mica flakes
4.4' – 8.7'	ML	-	-	39	81	35	4	-	SANDY SILT, reddish-brown with iron oxide staining, damp, very fine to medium angular to subangular grained sand, dense, non-cemented
8.7' – 9.1'	SM-SC	-	-	54	48	24	7	14	SILTY CLAYEY SAND, brown, very fine to medium angular to subangular grained sand, firm to stiff, non-cemented, $\gamma_d = 122.1$ PCF
9.1' – 11.1'		-	-	70	30	-	-	7	CLAYEY SAND, as above
11.1' – 12.0'	SC	-	-	-	-	-	-	-	*CLAYEY SAND, grey-brown, damp, estimated 75% fine grained sand, estimated 25% medium plasticity fines, high density, mica flakes
12.0' – 13.7'		-	-	-	-	-	-	-	*CLAYEY SAND, very dark grey-brown, damp, estimated 70-75% fine grained sand, estimated 25-30% medium plasticity fines, trace of hard subangular gravel to 3/4" maximum, low density, mica flakes
13.7' – 14.7'	SM-SP	-	43	46	11	-	-	9	SILTY GRAVELLY SAND, greyish-brown, very fine to coarse subangular to angular grained sand, angular gravel to 1-1/2" maximum, non-plastic fines, firm, non-cemented
14.7' – 15.4'		-	-	-	-	-	-	-	*CLAYEY GRAVELLY SAND, dark brown, damp, estimated 80% medium grained sand, estimated 15% hard subangular gravel to 2" maximum, estimated 5% low to medium plasticity fines, low density
15.4' – 16.2'	SC-SP	-	-	-	-	-	-	15	*CLAYEY GRAVELLY SAND, dark brown, estimated 70-75% coarse grained sand, estimated 20% hard subangular gravel to 1-1/2" maximum, estimated 5-10% low plasticity fines, low density
16.2' – 17.4'		-	-	-	-	-	-	-	*CLAYEY SAND, dark brown, damp, estimated 85-80% medium grained sand, estimated 5-10% low plasticity fines, estimated 5% hard subangular gravel to 3/4" maximum, low density
17.4' – 19.5'	(GP)	-	-	-	-	-	-	-	SANDY GRAVEL, greyish-brown, damp, estimated 50-60% subangular gravel to 3" maximum, estimated 40-50% very fine to fine grained sand, stiff, non-cemented

7 F - 5

Depth		GR	SA	FI	LL	PI	MC	Description
0 – 2.3'	ML	-	21	79	-	-	-	SANDY SILT, light grey, dry to damp, non-plastic fines, very fine to fine angular to subangular grained sand, slightly organic, firm, non-cemented
2.3' – 5.1'		-	82	38	30	8	-	SILTY SAND, brown, damp, very fine to medium grained sand, stiff to very stiff, non-cemented, (Decomposed Granite)
5.1' – 7.5'	SM	-	79	21	-	-	-	SILTY SAND, dark brown, moist, very fine to coarse angular grained sand, non-plastic fines, very dense, moderately cemented, (Decomposed Granite)
7.5' – 10.0'	(CL)	-	-	-	-	-	-	SANDY CLAY, brownish-grey, moist, est. 80-70% medium plasticity fines, est. 30-40% very fine grained sand, soft, non-cemented Void Space encountered, all drill water return lost
10.0' – 12.5'	SM-SW	-	61	9	23	4	14	SILTY SAND, brownish-grey, very fine to medium angular grained sand, firm to very firm density, non-cemented, $\gamma_d = 121.3$ PCF
12.5' – 14.0'	GP	84	14	2	-	-	5	GRAVEL, brownish-grey, subrounded gravel to 3" maximum, very fine to medium angular to subangular grained sand, firm density, non-cemented, (Decomposed Granite)
14.0' – 18.3'	SC	-	54	48	30	9	-	CLAYEY SAND, reddish-brown to brownish-grey, moist, very fine to fine angular to subangular grained sand, firm to very firm density, non-cemented
18.3' – 19.0'	GM	50	30	20	-	-	-	SILTY SANDY GRAVEL, brown, moist, gravel to 3" maximum, very fine to medium grained sand, non-plastic fines, firm density, non-cemented

Vertical Scale: 1" = 2'

7 F - 6

Depth		GR	SA	FI	LL	PI	MC	Description
0 – 2.8'	SC	12	57	31	33	12	25	CLAYEY SAND, dark brown, very fine to coarse grained sand, gravel to 3/4" maximum, medium to high organic content, firm density, non-cemented. $\gamma_d = 100.0$ PCF
2.8' – 5.0'	(F)	-	-	-	-	-	-	DECOMPOSED GRANITE, dark grey-black, moist, fine to medium grained, estimated 80-70% mafics, est. 30-40% quartz and feldspar, loose density, non-cemented, (Decomposed Granite)
5.0' – 7.7'	SP-SM	-	-	-	-	-	-	*SILTY GRAVELLY SAND, dark grey to very dark gray, damp, estimated 60% coarse grained sand, estimated 15% moderately hard to soft angular to subangular weathered gravel to 3" maximum, estimated 5% non-plastic fines, medium density, (Decomposed Granite)
7.7' – 10.4'		58	38	4	-	-	8	SANDY GRAVEL, dark grey-black, gravel to 1" maximum, very fine to coarse grained sand, hard, non-cemented, estimated 30-40% quartz and feldspar, estimated 60-70% mafics (Decomposed Granite). $G_s = 2.88$, $\gamma_d = 145.3$ PCF
10.4' – 13.0'	GW	50	48	4	-	-	45	SANDY GRAVEL, dark grey, gravel to 1" maximum, very fine to coarse grained sand (Decomposed Granite). $G_s = 2.88$, $\gamma_d = 129.5$ PCF
13.0' – 18.5'	SP-SM	-	-	-	-	-	-	*SILTY GRAVELLY SAND, dark gray, damp, estimated 70% coarse grained sand, estimated 25% moderately hard to soft angular to subangular grained weathered gravel to 2" maximum, estimated 5% non-plastic fines, (Decomposed Granite)

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			GROUP SYMBOLS	TYPICAL NAMES
COARSE GRAINED SOILS 50% or more retained on the No. 200 sieve.	GRAVELS More than half of coarse fraction retained on the No. 4 sieve.	Clean gravels	GW	Well-graded gravels, gravel-sand mixtures, little or no fines.
			GP	Poorly-graded gravels, gravel-sand mixtures, little or no fines.
		Gravels with fines	GM	Silty gravels, gravel-sand mixtures.
			GC	Clayey gravels, gravel-sand-clay mixtures.
	SANDS More than half of coarse fraction passing the No. 4 sieve.	Clean sands	SW	Well-graded sands, gravelly sands, little or no fines.
			SP	Poorly-graded sands, gravelly sands, little or no fines.
		Sands with fines	SM	Silty sands, sand-silt mixtures.
			SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS More than 50% passing the No. 200 sieve.	SILTS AND CLAYS	Liquid Limit below 50%	ML	Inorganic silts and very fine sands, rock flour, silty fine sands or silts. Plasticity below "A" line.
			CL	Inorganic clays, gravelly clays, sandy clays, lean clays. Plasticity above "A" line.
			OL	Organic silts and organic clays. Plasticity below "A" line.
		Liquid Limit 50% and above	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts. Plasticity below "A" line.
			CH	Inorganic fat clays. Plasticity above "A" line.
			OH	Organic clays or organic silts. Plasticity below "A" line.
Highly organic soils			Pt	Peat, organic content greater than 60%.

LEGEND:

GR	Gravel, percent by weight passing 3-inch sieve and retained on the No. 4 sieve.
SA	Sands, percent by weight passing the No. 4 sieve and retained on the No. 200 sieve.
FI	Fines, percent by weight passing the No. 200 sieve.
LL	Liquid Limit.
PI	Plasticity Index (Liquid Limit Minus Plastic Limit).
MC	Field Moisture Content in Percent of Dry Weight.
(CL)	Visual Field Classification.
*	Laboratory Visual Classification.
G_s	Specific Gravity. (Minus No. 4)
γ_d	Dry Unit Weight.
(F)	No Unified Soil Classification Available.

NOTES:

1. Classifications are in accordance with the Unified Soils Classification System (ASTM D-2487).
2. All sieve sizes on the chart are U.S. Standard.
3. The terms "silt" and "clay" are used respectively to distinguish materials exhibiting lower plasticity from those with higher plasticity. The minus No. 200 sieve material is silt if the liquid limit and plasticity index plot below the "A" line on the plasticity chart (ASTM D-2487) and is clay if the liquid limit and plasticity index plot above the "A" line on the chart.
4. Borderline Classification: Soils possessing characteristics of two groups are designated by combinations of group symbols. For example GW-GC, a well-graded gravel-sand mixture with a clay binder.
5. Borings 7F-1 through 7F-12 were drilled with a Mobile B-80 drill rig equipped with 8-inch pitcher tubes during 20-29 September 1982.
6. For additional logs of borings and trenches in the Fancher Creek Dam Site area, see sheet Nos. F8 – F15.
7. For location of borings, see sheet No. F6.
8. Depth to groundwater was not measured.

GRAPHIC SCALE

1" = 2' 0' 1' 2' 4' 6' 8' 10'

REVISION	DATE	DESCRIPTION	BY	BY
△				
△				

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DESIGNED: K. Swanson
DRAWN: K. Wohl
CHECKED: D. Anderson

REDBANK AND FANCHER CREEKS, CALIFORNIA
FANCHER CREEK

FANCHER CREEK DAM
LOGS OF EXPLORATIONS
7F-1 thru 7F-6

SUBMITTED: CHIEF, SOILS DESIGN SECTION
DATE APPROVED
SCALE
SPEC No.
SHEET
FILE No. SJ-11-20-11

ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING

7 F - 7

Depth		GR	SA	FI	LL	PI	MC	Description
0 – 2.5'	SM	-	64	36	-	-	17	SILTY SAND, light reddish-brown, very fine to coarse subangular to angular grained sand, non-plastic fines, slightly organic, loose, non-cemented. Yd = 106.7 PCF
2.5' – 3.7'		-	-	-	-	-	-	*SILTY SAND, dark yellowish-brown, damp, est. 80% very fine grained sand, est. 20% medium plasticity fines, low density, mica flakes
3.7' – 4.9'	CL	-	-	-	-	-	-	*SANDY CLAY, gray-brown, damp, est. 55% medium plasticity fines, est. 45% very fine grained sand, soft
4.9' – 6.3'	SC-SP	-	-	-	-	-	-	*CLAYEY GRAVELLY SAND, gray-brown, damp, est. 60% medium grained sand, est. 30% hard subangular gravel to 2" maximum, est. 10% medium plasticity fines, low density (Decomposed Granite)
6.3' – 7.6'	SC-SW	30	63	7	-	-	16	CLAYEY GRAVELLY SAND, as above. G_s = 2.64, Yd = 137.6 PCF
7.6' – 10.4'		-	-	-	-	-	-	*SAND, dark grey and white, damp, est. 100% coarse grained sand, high density, moderately decomposed mica flakes, (Decomposed Granite)
10.4' – 13.1'	SP	40	59	1	33	6	-	GRAVELLY SAND, dark grey to black, damp, medium to coarse grained sand, gravel to 1" maximum, dense, non-cemented, (Decomposed Granite)
13.1' – 14.4'		-	-	-	-	-	-	*SAND, dark grey to black, moist, mixed coarse and fine grained sand, (Decomposed Granite)
14.4' – 16.2'	SP-SM	15	73	12	-	-	-	SILTY GRAVELLY SAND, dark gray to black, damp, very fine to coarse grained sand, gravel to 1/2" maximum, dense, non-cemented, (Decomposed Granite), G_s = 2.90
16.2' – 18.4'	SP	-	-	-	-	-	-	*SAND, dark gray-brown, damp, est. 100% medium to coarse grained sand, trace of non-plastic fines, high density, moderately weathered mica flakes, (Decomposed Granite)

7 F - 8

Depth		GR	SA	FI	LL	PI	MC	Description
0 – 1.0'	SM	7	70	23	-	-	-	SILTY SAND, waste material from road fill
1.0' – 2.6'	CL	-	-	-	-	-	-	*SANDY CLAY, dark reddish-brown, damp, est. 55% medium plasticity fines, est. 45% medium grained sand, very stiff, mica flakes
2.6' – 3.6'	SP	-	-	-	-	-	-	*SAND, reddish-yellow, damp, est. 100% medium to coarse grained sand, traces of non-plastic fines, very dense, moderately weathered mica flakes and feldspars, (100% Decomposed Granite)
3.6' – 6.5'	SW	-	66	4	32	11	5	SAND, light tan and black with slight iron oxide staining, fine to coarse grained sand, (Decomposed Granite), Yd = 136.4 PCF
6.5' – 8.8'	SP	-	-	-	-	-	-	*SAND, reddish-yellow, est. 100% coarse grained sand, traces of non-plastic fines, very dense, moderately weathered feldspars, (100% Decomposed Granite)
8.8' – 11.3'	SW-SM	1	93	6	-	NP	4	SILTY SAND, as above except slight increase in fines, G_s = 2.73 (Decomposed Granite)
11.3' – 14.0'	SP	-	-	-	-	-	-	*SAND, light gray, damp, est. 100% coarse grained sand, traces of non-plastic fines, high density, moderately weathered feldspars, (100% Decomposed Granite)
14.0' – 15.7'	SW	6	69	3	-	NP	-	SAND, as above (Decomposed Granite)
15.7' – 18.2'	SP	-	-	-	-	-	-	*SAND, light gray, damp, est. 100% coarse grained sand, traces of non-plastic fines, high density, moderately weathered feldspars and micas (100% Decomposed Granite)
18.2' – 20.7'	SW	15	83	2	-	NP	-	GRAVELLY SAND, light grey, damp, high density (100% Decomposed Granite)

7 F - 9

Depth		GR	SA	FI	LL	PI	MC	Description
0 – 1.2'	SC	-	-	-	-	-	-	*CLAYEY SAND, dark brown, damp, est. 70% graded sand, est. 30% medium to high plasticity fines, low density, mica flakes
1.2' – 2.4'	CL	-	-	-	-	-	-	*SANDY CLAY, dark reddish-brown, damp, est. 85-90% medium to high plasticity fines, est. 10-15% medium grained sand, stiff
2.4' – 3.5'	SC-SW	-	90	10	34	14		CLAYEY SAND, brown, moist, stiff to very stiff
3.5' – 5.6'	SW	-	96	4	21	1	5	SAND, white and black with iron oxide staining, very fine to coarse grained sand, soft to hard, moderately to highly weathered, (Decomposed Granite)
5.6' – 8.6'	SP	-	-	-	-	-	-	*SAND, dark grey and white, damp, est. 100% coarse grained sand, moderately weathered mica flakes (Decomposed Granite)
8.6' – 10.6'	SC-SW	-	89	11	30	8	9	CLAYEY SAND, white and black with some iron oxide staining, very fine to coarse grained sand, (Decomposed Granite), Yd = 128.4 PCF
10.6' – 13.7'	SP-SM	-	95	5	38	11	5	SILTY SAND, white and black with little iron oxide staining, very fine to coarse grained sand, (Decomposed Granite)
13.7' – 15.1'	SC	-	-	-	-	-	-	*CLAYEY SAND, dark gray, damp, est. 85-90% coarse grained sand, est. 10-15% low plasticity fines, medium density, clay in 1/8-1/4" lenses, (Decomposed Granite)
15.1' – 16.1'	(SP-SC)	-	-	-	-	-	-	CLAYEY SAND, light gray, damp, est. 90% medium to coarse grained sand, est. 10% low plasticity fines, low density, highly decomposed feldspar and mica, (Decomposed Granite)
16.1' – 18.4'	SW	26	71	3	-	NP	5	GRAVELLY SAND, dark gray to black with some iron oxide staining, very fine to coarse grained sand, soft, highly weathered (Decomposed Granite), Yd = 146.0 PCF

7 F - 10

Depth		GR	SA	FI	LL	PI	MC	Description
0 – 2.3'	SM	-	51	49	47	6	-	SILTY SAND, light brown to brown, damp, very fine to coarse grained sand, slightly organic, soft, non-cemented
2.3' – 4.7'		-	56	44	-	-	-	CLAYEY SAND, light yellowish-green, damp to moist, very fine to coarse grained sand, very soft, weathered, (Decomposed Granite)
4.7' – 7.4'	SC	-	-	-	-	-	-	*CLAYEY SAND, light grey-brown, damp, est. 70-75% medium grained sand, est. 25-30% medium plasticity fines, low density, (Decomposed Granite)
7.4' – 10.2'	CL	-	47	53	-	-	34	SANDY CLAY, light yellowish-green, damp to moist, very fine to medium grained sand, (Decomposed Granite), G_s = 2.76
10.2' – 12.6'	SC	-	-	-	-	-	-	*CLAYEY SAND, light grey-brown, damp, est. 60% fine to medium grained sand, est. 40% medium to high plasticity fines, low density, weathered feldspars, mica flakes, (Decomposed Granite)
12.6' – 14.8'	ML	-	46	51	18	12	-	SANDY SILT, light yellowish-green, damp to moist, very fine to medium grained sand, (Decomposed Granite)
14.8' – 16.5'	SC	-	-	-	-	-	-	*CLAYEY SAND, gray-brown, damp, est. 60% fine to medium grained sand, est. 40% medium plasticity fines, high density, mica flakes, (Decomposed Granite)
16.5' – 18.1'	(CL)	-	-	-	-	-	-	SANDY CLAY, light yellowish-green, damp to moist, fine grained sand, very soft, weathered, can be molded with fingers, (Decomposed Granite)
18.1' – 19.7'	CL	-	-	-	-	-	-	*SANDY CLAY, pale olive, damp, est. 60-65% medium to high plasticity fines, est. 35-40% fine grained sand, (Decomposed Granite)

7 F - 11

Depth		GR	SA	FI	LL	PI	MC	Description
0 – 2.3'	CH	-	33	67	54	36	23	SANDY CLAY, brown, very fine to medium grained sand, slightly organic, firm consistency, non-cemented, Yd = 100.9 PCF
2.3' – 4.9'		-	-	-	-	-	-	*SANDY CLAY, dark brown, damp, est. 60-65% medium plasticity fines, est. 35-40% fine grained sand, very stiff consistency, organic material, mica flakes
4.9' – 7.3'	CL	-	39	61	-	-	-	SANDY CLAY, as above, G_s = 2.78
7.3' – 9.5'		-	-	-	-	-	-	SANDY CLAY, as above except est. 50-60% fines, est. 40-50% sand
9.5' – 9.9'		-	-	-	-	-	-	*CLAYEY SAND, light reddish-brown, damp, est. 80-85% graded sand, est. 15-20% medium plasticity fines, stiff consistency, mica flakes
9.9' – 12.7'		-	86	14	39	18	-	CLAYEY SAND, as above
12.7' – 15.4'	SC	-	90	10	-	-	-	CLAYEY SAND, light tan to black with iron oxide staining, moist, very fine to coarse grained sand, soft, est. 60-65% quartz and feldspars, est. 35-40% mafic and biotite, (Decomposed Granite)
15.4' – 15.8'	CL	-	-	-	-	-	-	*SANDY CLAY, reddish-brown, damp, est. 55-60% medium plasticity fines, est. 40-45% fine grained sand, hard, mica flakes, (Decomposed Granite)
15.8' – 18.0'	SC	-	-	-	-	-	-	*CLAYEY SAND, red-brown, damp, est. 60-65% fine grained sand, est. 35-40% medium plasticity fines, low density, (Decomposed Granite)
18.0' – 20.2'	SP	-	66	4	24	3	7	SAND, light tan to black with iron oxide staining, moist, very fine to coarse grained sand, soft, est. 60-65% quartz and feldspars, est. 35-40% mafic and biotite, (Decomposed Granite), Yd = 130.8 PCF

7 F - 12

Depth		GR	SA	FI	LL	PI	MC	Description
0 – 2.6'	ML-CL	-	46	54	19	7	12	SANDY SILT, brown, very fine to medium grained sand, slightly organic, firm to stiff consistency, non-cemented, Yd = 111.0 PCF
2.6' – 5.4'	(CL)	-	-	-	-	-	-	SANDY CLAY, reddish-brown, moist, est. 75-85% medium to high plasticity fines, est. 15-25% very fine grained sand, slightly organic, firm to stiff consistency, non-cemented
5.4' – 7.7'		3	52	45	24	1	21	SILTY SAND, dark reddish-brown, very fine to coarse angular to subangular grained sand, firm density, non-cemented, Yd = 108.4 PCF
7.7' – 10.3'	SM	-	71	29	-	-	-	SILTY SAND, as above except moderately to highly cemented
10.3' – 12.4'	SC	-	-	-	-	-	-	*CLAYEY SAND, dark brown, damp, est. 85-90% fine grained sand, est. 10-15% low to medium plasticity fines, low density, mica flakes
12.4' – 15.0'	SM	-	82	18	-	-	-	SILTY SAND, light brownish-grey, very fine to coarse grained sand, low plasticity fines, firm density, non-cemented
15.0' – 16.7'		-	97	3	29	4	5	SAND, light yellowish-tan and brown, very fine to coarse angular grained sand, low plasticity fines, non-cemented, mica, quartz fragments, (Decomposed Granite), Yd = 145.0 PCF
16.7' – 18.7'	SP	-	96	4	-	-	5	SAND, white and black with slight iron oxide staining, very fine to coarse grained sand, soft to hard, est. 50-60% quartz and weathered feldspar, est. 40-50% mafics and biotite (Decomposed Granite)

Vertical Scale: 1" = 2'

NOTES:

1. For additional notes and legend, see sheet No. F10.
2. For additional logs of borings and trenches in the Fancher Creek Dam Site area, see sheet Nos. F8-F15
3. For location of borings, see sheet No. F6.

GRAPHIC SCALE

0 1' 2' 4' 6' 8' 10'

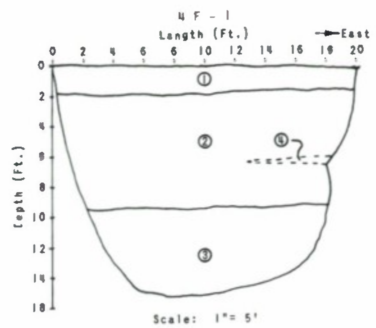
REVISION	DATE	DESCRIPTION	BY	BY

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DESIGNED: K. Swenson
DRAWN: K. Wohl
CHECKED: D. Anderson

REDBANK AND FANCHER CREEKS, CALIFORNIA
FANCHER CREEK
FANCHER CREEK DAM
LOGS OF EXPLORATIONS
7F-7 thru 7F-12

SUBMITTED: Clark C. Stengel
CHIEF, SOILS DESIGN SECTION
DATE APPROVED: 4/22/86
SCALE:
SPEC. No.
SHEET F 11 / 64
FILE No. SJ-11-20-11

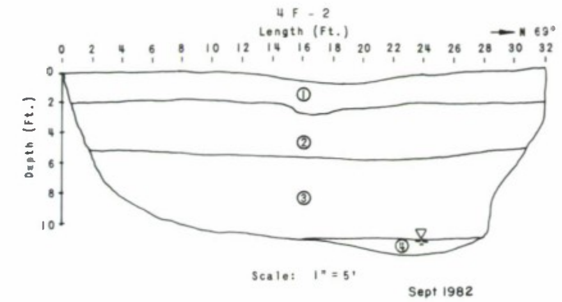


① SANDY CLAY (CL), dark brown, 18% moisture content, 64% medium plasticity fines, (LL = 35, PI = 21), 36% very fine to medium subangular to angular grained sand, slightly organic, firm density, non-cemented

② SANDY SILT (ML), reddish-brown with abundant iron oxide staining, 10% moisture content, 74% non-plastic fines, 26% very fine to medium angular grained sand, very firm to firm consistency, slightly cemented with irregular streaks of white material, numerous highly weathered fragments, mica flakes

③ SANDY SILT (ML), light greenish-gray to brownish-gray with irregular streaks of iron oxide staining, 18% moisture content, 84% non-plastic fines, 36% very fine to medium angular grained sand, mica flakes

④ SILTY SAND, as at 2, but contains no weathered rock fragments nor any cementation (F.C.)

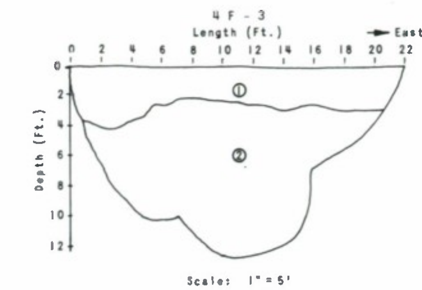


① *SANDY CLAY (CL), light red-brown, est. 60% medium plasticity fines, est. 35% medium grained sand, est. 5% hard subangular gravel to 1" maximum

② SANDY SILT (ML), light reddish-brown with iron oxide staining, 85% non-plastic fines, 35% very fine to medium subangular grained sand, very dense to dense, slightly cemented

③ SILTY SAND (SM), light greenish-gray with irregular zones of iron oxide staining, damp, 93% very fine to coarse grained sand, 28% non-plastic fines, 9% gravel to 3/8" maximum, firm to stiff, non-cemented to slightly cemented

④ SILTY SAND (SM), reddish-brown with iron oxide staining, moist to saturated, 66% very fine to coarse subangular grained sand, 34% non-plastic fines, scattered rounded gravels to 1/4" maximum observed in field, loose to firm, non-cemented



① CLAYEY SAND (SC), dark brown with iron oxide staining, damp, 87% very fine to coarse angular grained sand, 32% low plasticity fines, (LL = 25, PI = 12), 1% gravel to 1" maximum, slightly organic, soft to firm, non-cemented

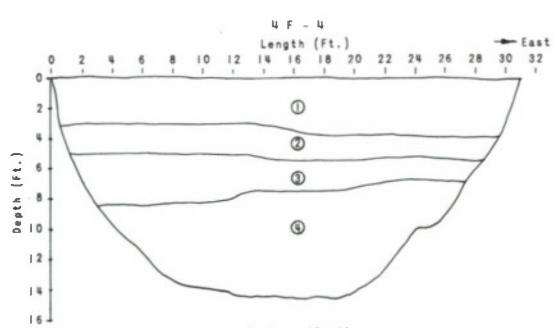
② CLAYEY SAND (SC-SW), light gray, 4% moisture content, 93% very fine to coarse angular grained sand, 11% medium plasticity fines (LL = 34, PI = 14), 6% gravel to 3/8" maximum, highly weathered, breaks down under finger pressure, composed of quartz, feldspar, mafics and biotite (Decomposed Granite)

LEGEND:

LL	Liquid Limit.
PI	Plasticity Index (Liquid Limit Minus Plastic Limit).
(F.C.)	Visual Field Classification.
*	Laboratory Visual Classification.
∇	Groundwater Level.
(SC)	Unified Soil Classification.

NOTES:

1. Classifications are in accordance with the Unified Soils Classification System (ASTM D-2487).
2. All sieve sizes on the chart are U.S. Standard.
3. The terms "silt" and "clay" are used respectively to distinguish materials exhibiting lower plasticity from those with higher plasticity. The minus No. 200 sieve material is silt if the liquid limit and plasticity index plot below the "A" line on the plasticity chart (ASTM D-2467) and is clay if the liquid limit and plasticity index plot above the "A" line on the chart.
4. Borderline Classifications: Soils possessing characteristics of the two groups are designated by combinations of group symbols. For example GW-GC, a well-graded gravel-sand mixture with a clay binder.
5. Trenches 4F-1 through 4F-5 were dug with a backhoe during 14-18 September 1982.
6. For additional logs of borings and trenches in the Fancher Creek Dam Site area, see sheet Nos. F8 - F15.
7. For location of trenches, see sheet No. F6 .
8. Groundwater was encountered during explorations.

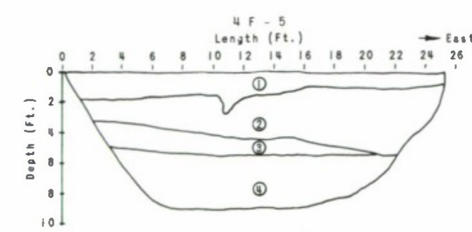


① SANDY CLAY (CL), brown, dry to damp, 50% low plasticity fines (LL = 25, PI = 8), 49% very fine to medium grained sand, 1% gravel to 3/8" maximum, slightly organic, firm consistency, non-cemented

② *CLAYEY SAND (SC), brown, dry to damp, est. 81% very fine to medium grained sand, est. 18% low to medium plasticity fines, est. 1% gravel to 3/4" maximum, irregular layers and lenses of white to tan cementing material

③ SILTY SAND (SM-SW), reddish-brown, damp, 89% well graded angular to subangular grained sand, 9% non-plastic fines, 2% gravel to 3/8" maximum, loose to firm, non-cemented

④ DECOMPOSED GRANITE, light brownish-gray, damp, est. 50-60% quartz and feldspar, est. 40-50% mafics and biotite, breaks down to very fine to coarse angular fragments, (F.C.)



① SANDY CLAY (CL), dark brown, damp, 53% medium plasticity fines (LL = 36, PI = 23), 48% very fine to medium angular grained sand, 1% fine gravel to 3/8" maximum, slightly organic, hard, non-cemented, desiccation cracks to 1.5' depth

② SILTY SAND (SM), reddish-brown with heavy iron oxide stains, 79% very fine to coarse angular grained sand, 16% non-plastic fines, 3% gravel to 1" maximum, dense to very dense, moderately cemented

③ SILTY SAND (SM), dark grayish-brown with moderate iron oxide staining, 10% moisture content, 58% well graded angular to subangular grained sand, 34% low plasticity fines (LL = 23, PI = 4), 8% gravel to 1-1/2" maximum, very dense, moderately cemented

④ SILTY SAND (SM-SW), light brownish-gray with slight iron oxide staining, 3% moisture content, 80% well graded sand, 11% gravel to 3/4" maximum, 9% fines, composed of quartz, feldspar, mafics and biotite (Decomposed Granite)

GRAPHIC SCALE

REVISION	DATE	DESCRIPTION	BY	BY

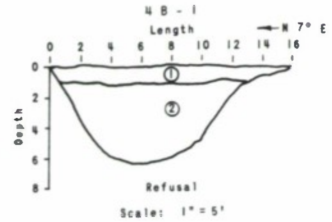
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DESIGNED: K. Swanson
DRAWN: K. Swanson
CHECKED: D. Anderson

REDBANK AND FANCHER CREEKS, CALIFORNIA
FANCHER CREEK
FANCHER CREEK DAM
LOGS OF EXPLORATIONS
4F-1 thru 4F-5

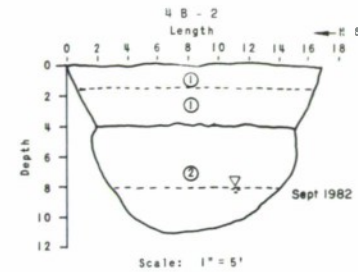
SUBMITTED: [signature] CHIEF, SOILS DESIGN SECTION
DATE APPROVED: 4/22/85
SCALE:
SPEC. No.
SHEET F 12 65
FILE No. SJ-11-20-11

ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING



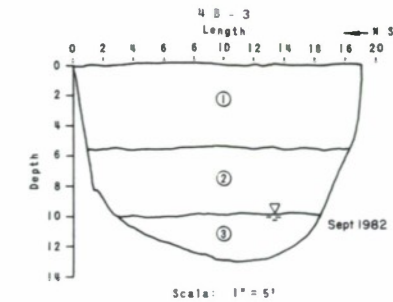
① CLAYEY SAND (SC-SM), light brown with iron oxide staining, 1% moisture content, 73% very fine to medium angular grained sand, 27% low plasticity fines (LL = 22, PI = 7), composed of quartz, mafics, and scattered mica flakes

② CLAYEY SAND (SC-SP), light reddish-brown, 6% moisture content, 90% very fine to coarse angular grained sand, 10% fines, non-cemented, dense to very dense, composed of quartz fragments, mafics and mica. (Decomposed Granite)



① SANDY CLAY (CL-ML), light brown, dry to damp, 87% low plasticity fines (LL = 20, PI = 8), 33% very fine to medium angular grained sand, slightly organic, very stiff to firm consistency, primarily quartz, at 1.5' depth 1" to 1-1/2" thick cemented zone "caliche"

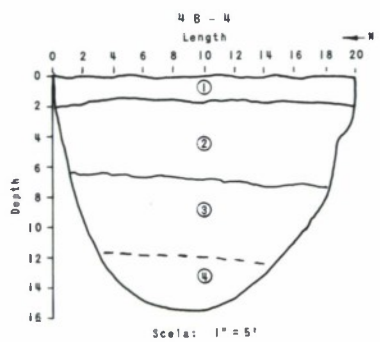
② SILTY SAND (SM-SW), light gray, moist to saturated, 83% well graded sand, 11% fines, 8% gravel to 1" maximum, loose to firm density, non-cemented, composed of angular quartz, mafics, and mica



① SANDY SILT (ML), brown, 24% moisture content, 55% fines, 45% very fine to medium grained sand, slightly organic, soft, non-cemented

② SANDY CLAY (CL), light brown, 19% moisture content, 54% low plasticity fines (LL = 29, PI = 12), 46% very fine angular to subangular grained sand, non-cemented

③ GRAVELLY SAND (SW), light brown to light gray, saturated, 69% well graded sand, 27% gravel to 3" maximum, 4% fines, scattered cobbles to 4" observed in field, loose to very firm density, composed of quartz and mafics

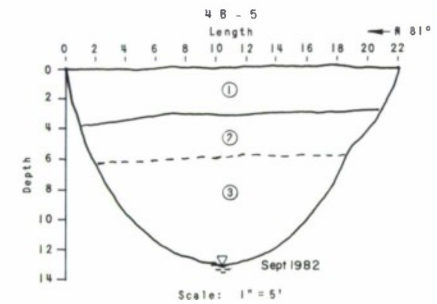


①*SANDY CLAY (CL), red-brown, dry to damp, est. 55% medium plasticity fines, est. 45% fine to medium grained sand, traces of gravel to 3/8" maximum

② CLAYEY SAND (SC), reddish-brown with iron oxide staining, damp, 79% very fine to coarse angular grained sand, 15% medium plasticity fines, (LL = 31, PI = 13), 6% gravel to 3/8" maximum, quartz, feldspars, mica flakes, (Decomposed Granite)

③ CLAYEY SAND (SC-SW), light reddish-grey, damp, 81% well graded sand, 12% gravel to 3/8" maximum, 7% medium plasticity fines (LL = 39, PI = 17), (Decomposed Granite)

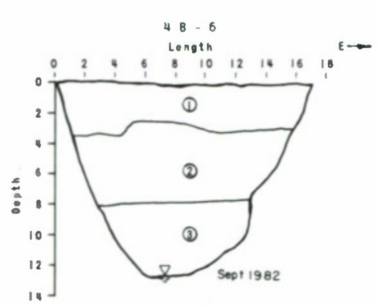
④ CLAYEY GRAVELLY SAND (SC-SW), light to medium gray, damp, 78% well graded sand, 16% gravel to 3/8" maximum, 6% fines, (Decomposed Granite)



① SANDY CLAY (CH), dark brown, 18% moisture content, 72% high plasticity fines (LL = 72, PI = 50), 27% very fine to fine angular grained sand, 1% gravel to 1/2" maximum, firm to very firm consistency, non-cemented, desiccation cracks extend down to top of Decomposed Granite, shrinkage limit = 8%

② CLAYEY GRAVELLY SAND (SC-SW), light reddish-gray with iron oxide staining, 11% moisture content, 76% well graded angular grained sand, 15% gravel to 1/2" maximum, 9% fines, highly weathered, composed of quartz, feldspar, mafics and biotite (Decomposed Granite)

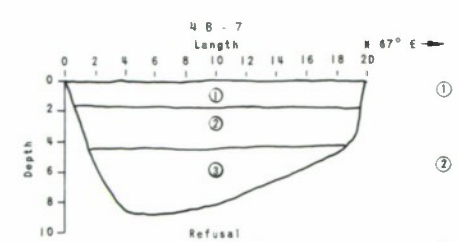
③ CLAYEY GRAVELLY SAND (SC-SW), light to medium gray, 5% moisture content, 83% well graded angular grained sand, 11% gravel to 1/2" maximum, 6% fines, (Decomposed Granite)



① SANDY CLAY (CL), dark reddish-brown, damp to moist, 51% medium plasticity fines (LL = 30, PI = 18), 46% very fine to medium subangular to angular grained sand, 1% gravel to 1/2" maximum, slightly organic, soft to firm consistency, non-cemented, G_s = 2.78

② SANDY SILT (ML), reddish-brown with iron oxide staining, 17% moisture content, 60% non-plastic fines, 40% very fine to medium subangular to angular grained sand, very firm to dense, non-cemented

③ SANDY CLAY (CL), light brownish-grey with irregular streaks of iron oxide staining, 16% moisture content, 52% medium plasticity fines (LL = 30, PI = 9), 46% very fine to medium grained sand, firm consistency, non-cemented, abundant small flakes of mica



① SANDY GRAVELLY CLAY (CH), dark brown, 10% moisture content, 57% high plasticity fines (LL = 59, PI = 41), 25% subrounded to subangular gravel to 3" maximum, 18% very fine to coarse grained sand, slightly organic, hard, non-cemented

② SILTY SANDY GRAVEL (GM-GW) light reddish-brown with iron oxide staining, 10% moisture content, 64% subrounded gravel to 3" maximum (mostly fine gravel), 29% very fine to medium subangular to subrounded grained sand, 7% non-plastic fines, dense to very dense, slightly to moderately cemented

③ CLAYEY GRAVELLY SAND (SC-SW), medium to dark gray, 7% moisture content, 66% well graded angular grained sand, 25% gravel to 3" maximum (mostly fine gravel), 7% medium plasticity fines (LL = 33, PI = 10), highly weathered, composed of quartz, feldspar, mafics and biotite (Decomposed Granite)

LEGEND:

LL	Liquid Limit.
PI	Plasticity Index (Liquid Limit Minus Plastic Limit).
(F.C.)	Visual Field Classification.
*	Laboratory Visual Classification.
▽	Groundwater Level.
(SC)	Unified Soil Classification.
G_s	Specific Gravity (Minus No. 4)

NOTES:

1. Classifications are in accordance with the Unified Soils Classification System (ASTM D-2487).
2. All sieve sizes on the chart are U.S. Standard.
3. The terms "silt" and "clay" are used respectively to distinguish materials exhibiting lower plasticity from those with higher plasticity. The minus No. 200 sieve material is silt if the liquid limit and plasticity index plot below the "A" line on the plasticity chart (ASTM D-2487) and is clay if the liquid limit and plasticity index plot above the "A" line on the chart.
4. Borderline Classifications: Soils possessing characteristics of the two groups are designated by combinations of group symbols. For example GW-GC, a well-graded gravel-sand mixture with a clay binder.
5. Trenches 4B-1 through 4B-12 were dug with a backhoe during 13-16 September 1982.
6. For additional logs of borings and trenches in the Fancher Creek Dam Site area, see sheet Nos. F8 - F15.
7. For location of trenches see sheet No. F6 .
8. Groundwater was encountered during explorations.

GRAPHIC SCALE

1" = 5' 0' 5' 10' 15' 20' 25'

REVISION	DATE	DESCRIPTION	BY

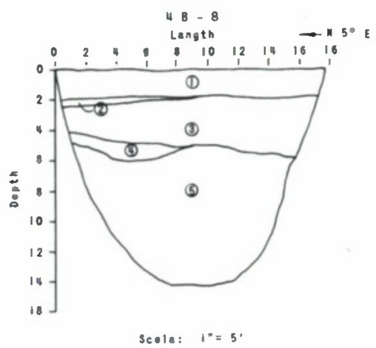
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DESIGNED: K. Swanson
DRAWN: K. Swanson
CHECKED: D. Anderson
SUBMITTED: Chief, Soils Design Section

REDBANK AND FANCHER CREEKS, CALIFORNIA
FANCHER CREEK
FANCHER CREEK DAM
LOGS OF EXPLORATIONS
4B-1 thru 4B-7

DATE APPROVED: 4/23/86
SCALE:
SHEET: F13 / 66
FILE No.: SJ-11-20-11
SPEC. No.:

ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING



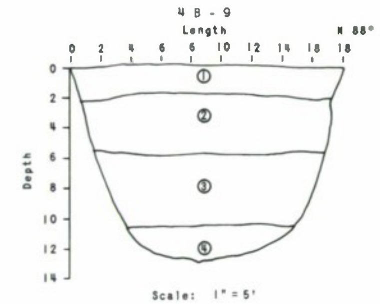
① *SANDY CLAY (CL), red-brown, 16% moisture content, est. 65-70% medium plasticity fines, est. 25-30% fine to medium grained sand, est. 5% hard gravel to 1-1/2" maximum, slightly organic, stiff to hard consistency, non-cemented

② GRAVELLY SILTY SAND (SM), reddish-brown with iron oxide staining, damp, est. 60-65% fine to coarse grained sand, est. 25-30% non-plastic fines, est. 10%-15% subrounded gravel to 2" maximum, dense, slightly cemented. (F.C.)

③ CLAYEY SAND (SC), reddish-brown with iron oxide staining, 13% moisture content, 76% very fine to medium angular grained sand, 22% high plasticity fines (LL = 50, PI = 32), 2% gravel to 3/4" maximum, dense to very dense, slightly cemented, abundant mica

④ GRAVELLY SILTY SAND (SM), same as material 2 except gravel to 3" maximum

⑤ SILTY SAND (SM - SW), light gray, 7% moisture content, 62% very fine to coarse angular grained sand, 11% medium plasticity fines (LL = 38, PI = 12), 7% gravel to 3/4" maximum, highly weathered, contains quartz, feldspar, mafics and biotite (Decomposed Granite). G_s = 2.71

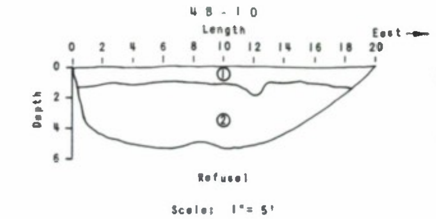


① SANDY CLAY (CH), dark brown, dry to damp, 71% high plasticity fines (LL = 54, PI = 35), 28% very fine to medium grained sand, 1% gravel to 3/4" maximum, slightly organic, firm to very stiff consistency, non-cemented, desiccation cracks to 1.5' depth, shrinkage limit = 9%

② SILTY SAND (SM), reddish-brown with iron oxide staining, 50% fines, 50% very fine to medium angular to subangular grained sand, very firm to very dense, slightly cemented

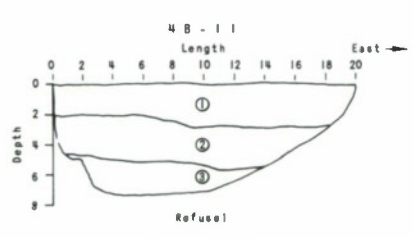
③ SANDY CLAY (CL), light greenish-gray with irregular sections of white to tan, damp, 52% medium plasticity fines (LL = 39, PI = 18), 48% very fine to medium grained sand, very firm to dense, non-cemented

④ CLAYEY SAND (SC), light reddish-gray with iron oxide staining, 9% moisture content, 82% well graded sand, 13% medium plasticity fines (LL = 35, PI = 15), 5% fine gravel to 3/4" maximum, composed of quartz, feldspar, mafics, and biotites (Decomposed Granite)



① SANDY CLAY (CL), medium brown, dry to damp, est. 60-70% medium plasticity fines, est. 30-40% very fine to fine grained sand, slightly organic, very firm consistency, non-cemented (F.C.)

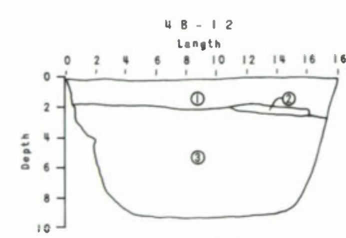
② CLAYEY GRAVELLY SAND (SC-SW), light reddish-grey with slight iron oxide staining, 2% moisture content, 58% well graded sand, 37% gravel to 3" maximum, 5% fines, composed of quartz, feldspar, mafics, and biotite (Decomposed Granite)



① CLAYEY SAND (SC), dark brown, 7% moisture content, 56% very fine to medium angular to subangular grained sand, 43% low plasticity fines (LL = 23, PI = 8), 1% gravel to 3/4" maximum, stiff to hard, non-cemented, desiccation cracks to 1.5' depth, G_s = 2.75

② SILTY GRAVELLY SAND (SM-SW), reddish-brown with iron oxide staining, 5% moisture content, 52% well graded sand, 36% gravel to 3" maximum, 10% fines, firm to very firm, non-cemented

③ CLAYEY GRAVELLY SAND (SC-SW), light brownish-grey, 6% moisture content, 79% well graded sand, 15% gravel to 1/2" maximum, 9% fines, composed of quartz, feldspar, mafics and biotite (Decomposed Granite)



① *SANDY CLAY (CL), light red-brown, est. 55% medium plasticity fines, est. 40% fine to medium grained sand, est. 5% hard subangular gravel to 3/4" maximum

② SILTY SAND (SM), brown with slight iron oxide staining, damp, est. 50-60% fine to medium angular to subangular grained sand, est. 40-50% low plasticity fines, very firm, slightly cemented (F.C.)

③ CLAYEY SAND (SC-SW), light brownish-gray, 9% moisture content, 78% very fine to coarse angular grained sand, 12% fines, 10% gravel to 3/4" maximum, composed of quartz, feldspar, mafics and biotite (Decomposed Granite), G_s = 2.72

NOTES:

1. For notes and legend, see sheet No. F13.
2. For additional logs of borings and trenches in the Fancher Creek Dam Site area, see sheet Nos. F8-F15.
3. For location of trenches, see sheet No. F6 .

GRAPHIC SCALE

1" = 5' 0' 5' 10' 15' 20' 25'

REVISION	DATE	DESCRIPTION	BY	BY

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

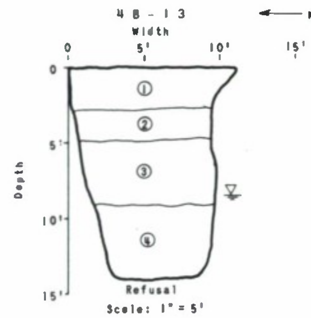
DESIGNED: K. Swanson
DRAWN: K. Swanson
CHECKED: D. Anderson

REDBANK AND FANCHER CREEK, CALIFORNIA
FANCHER CREEK

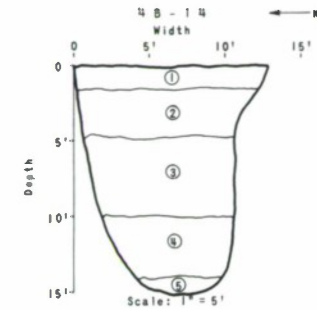
FANCHER CREEK DAM
LOGS OF EXPLORATIONS
4B-8 thru 4B-12

SUBMITTED: CHIEF, SOILS DESIGN SECTION
DATE APPROVED: 4/22/86
SCALE:
SPEC. No.
SHEET F 14 / 67
FILE No. SJ-11-20-11

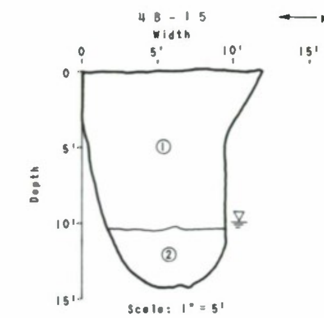
ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING



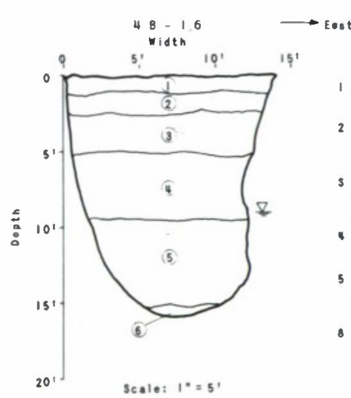
1 SANDY CLAY (CL), dark brown, dry, est. 60-70% fines, est. 30-40% very fine grained sand, highly organic, dense, brittle (F.C.)
2 SILTY SAND with COBBLES (SM), reddish-brown, damp, est. 60-70% fine to coarse grained sand, est. 20% low plasticity fines, est. 10-20% subrounded cobbles to 8" size, loose to firm, non-cemented (F.C.)
3 SANDY CLAY (CL), greenish-grey, moist, est. 70-80% fines, est. 20-30% fine to medium grained sand, firm, non-cemented (F.C.)
4 CLAYEY SAND (SC), greenish-grey, moist to wet, est. 90% fine to coarse angular grained sand, est. 10% low plasticity fines, firm to very firm. (Decomposed Granite) (F.C.)



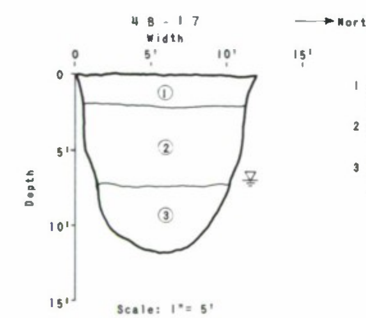
1 SANDY CLAY (CH), dark brown, dry to wet, est. 70-80% high plasticity fines, est. 20-30% very fine grained sand, highly organic, dense to very dense, brittle where dry (F.C.)
2 SILTY SAND with COBBLES (SM), reddish-brown, damp to moist, est. 60-70% fine to coarse grained sand, est. 20% low plasticity fines, est. 10-20% subangular to subrounded cobbles, loose to firm (F.C.)
3 CLAYEY SAND (SC), reddish-brown, moist, est. 70% fine to coarse grained sand, est. 30% fines, firm, non-cemented (F.C.)
4 GRAVELLY SAND (SW), brownish-grey, wet to saturated, est. 80-90% fine to coarse angular grained sand, est. 10-20% rounded gravel to 3/4" size, firm, non-cemented (F.C.)
5 SILTY SAND (SM), greenish-grey, wet, est. 80% angular fine to coarse grained sand, est. 20% fines, firm to very dense (Decomposed Granite) (F.C.)



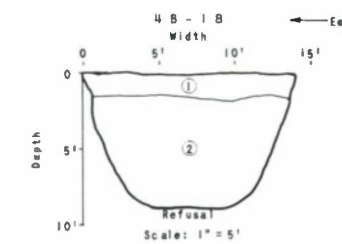
1 SANDY CLAY (CL), brown, dry to wet, est. 80-90% low to medium plasticity fines, est. 10-20% very fine grained sand, soft to firm, non-cemented (F.C.)
2 CLAYEY SAND (SC), dark grey, wet, est. 80-90% fine to coarse angular grained sand with fragments of granitics to 1" size, 10-20% fines, firm to very dense (Decomposed Granite) (F.C.)



1 SAND CLAY (CL), dark brown, dry, est. 70-80% fines, est. 20-30% very fine grained sand, stiff to very stiff, non-cemented, brittle (F.C.)
2 SILTY SAND with COBBLES (SM), reddish-brown, dry, est. 60-70% fine to coarse grained sand, est. 20% low plasticity fines, est. 10-20% cobbles to 4" size, dense to very dense, slightly cemented (F.C.)
3 SANDY SILT (ML), dark reddish-brown with white streaks, dry, est. 70-80% low plasticity fines, est. 20-30% very fine to medium grained sand, very dense in some areas, moderately cemented (F.C.)
4 SILTY SAND (SM), reddish-brown, moist, est. 70-80% fine to coarse grained sand, est. 20-30% low plasticity fines, firm, non-cemented (F.C.)
5 CLAYEY SAND (SC), greenish-grey, wet, est. 70-75% fine to coarse angular grained sand, est. 25-30% high plasticity fines, scattered rounded gravels, cobbles to 8" size, firm, non-cemented (F.C.)
6 SILTY SAND (SM), dark grey, wet, fine to coarse angular grained sand, non to low plasticity fines (Decomposed Granite) (F.C.)



1 SANDY SILT (ML), dark brown, dry to damp, est. 70-80% medium to high plasticity fines, est. 20-30% very fine grained sand, dense to very dense, brittle (F.C.)
2 SILTY SAND (SM), brown, moist to wet, est. 70-80% fine to coarse angular grained sand, est. 20-30% low plasticity fines, firm to very firm, non-cemented (F.C.)
3 SILTY SAND (SM), light to dark grey, wet, est. 80-90% fine to coarse angular grained sand, est. 10-20% low plasticity fines, dense to very dense (F.C.)



1 SANDY CLAY (CL), dark brown, dry to damp, est. 70-80% medium to high plasticity fines, est. 20-30% very fine to medium grained sand, stiff to very stiff brittle where dry, surface exhibits desiccation cracks 12"-18" deep (F.C.)
2 SILTY SAND (SM), tannish-grey to dark grey, damp, est. 80-80% very fine to coarse grained sand, est. 10-20% non to low plasticity fines, dense to very dense, fragments of weathered granitics to 10" size (Decomposed Granite) (F.C.)

NOTES:

1. For notes and legend, see Sheet No. F13.
2. For additional logs of borings and trenches in the Fancher Creek Dam Site area, see Sheet No. F9 F14.
3. For locations of trenches, see Sheet No. F6.

GRAPHIC SCALE

1" = 5' 0 5' 10' 15' 20' 25'

REVISION	DATE	DESCRIPTION	BY	BY

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

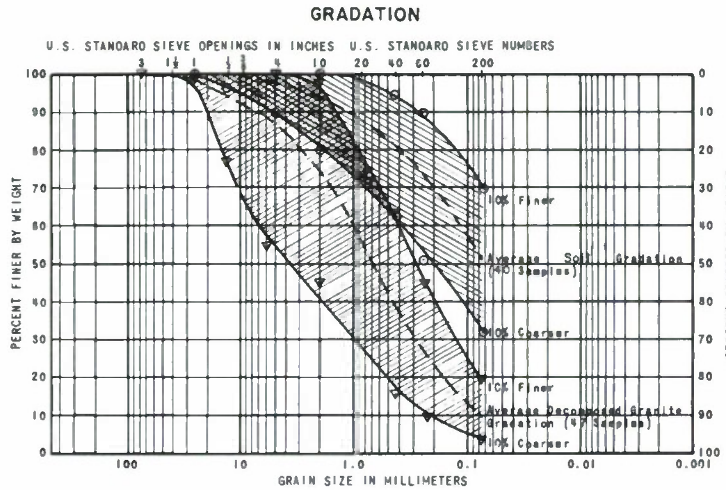
DESIGNED: K. Swanson
DRAWN: K. Wahl
CHECKED: D. Anderson

REDBANK AND FANCHER CREEKS, CALIFORNIA
FANCHER CREEK

FANCHER CREEK DAM
LOGS OF EXPLORATIONS
4B-13 thru 4B-18

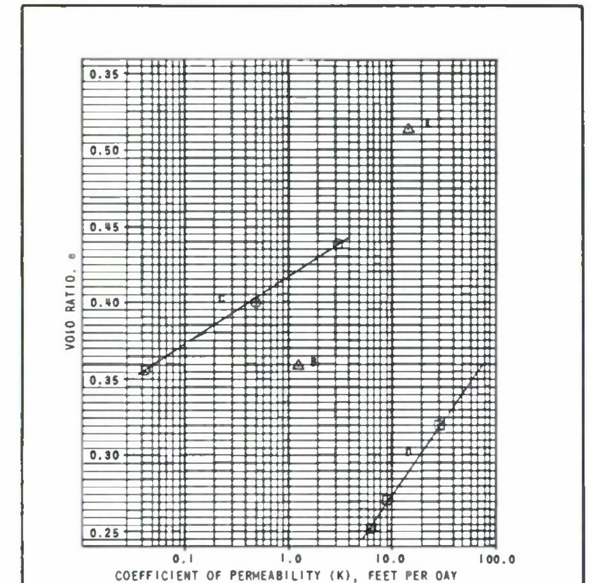
SUBMITTED:
CHIEF, SOILS DESIGN SECTION
DATE APPROVED:
SCALE:
SPEC. No.
SHEET F 15
68
FILE No. SJ-11-20-11

GRADATION



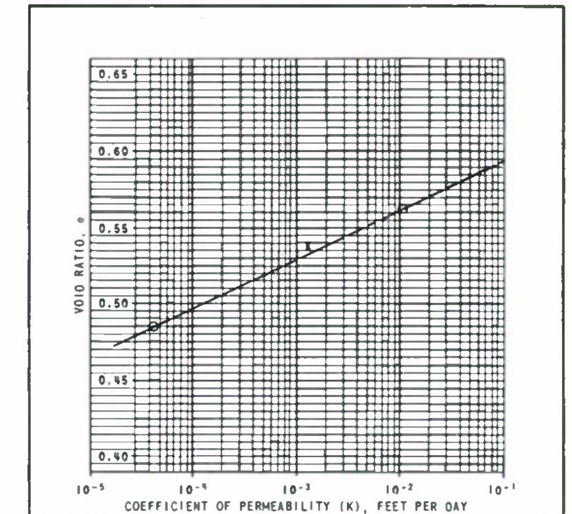
COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

PERMEABILITY



SYMBOL	MATERIAL	HOLE	DEPTH (Feet)	CONDITION
A	CLAYEY SAND (SC)	7F-7	5.3-7.9	Undisturbed (76% Sand, 22% Fines)
B	SILTY GRAVELLY SAND (SP-SM)	7F-7	14.4-16.2	Undisturbed (15% Gravel, 73% Sand, 12% Fines)
C	SILTY SAND (SP-SM)	7F-1	8.0-9.5	Undisturbed (69% Sand, 11% Fines)
D	GRAVEL (GP)	7F-5	12.5-14.0	Undisturbed (64% Gravel, 14% Sand, 2% Fines)

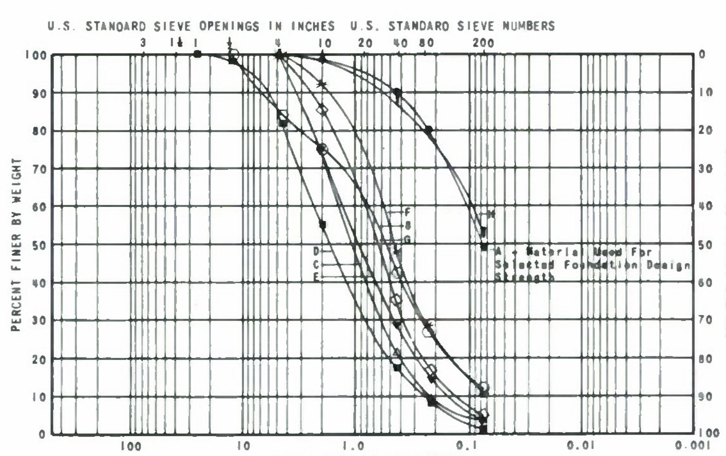
PERMEABILITY



SYMBOL	MATERIAL	HOLE	DEPTH (Feet)	CONDITION
A	SANDY SILT (ML-CL)	7F-12	0-2.6	Undisturbed (48% Sand, 54% Fines)

Used for permeability estimates of elluvium (Composite 6).

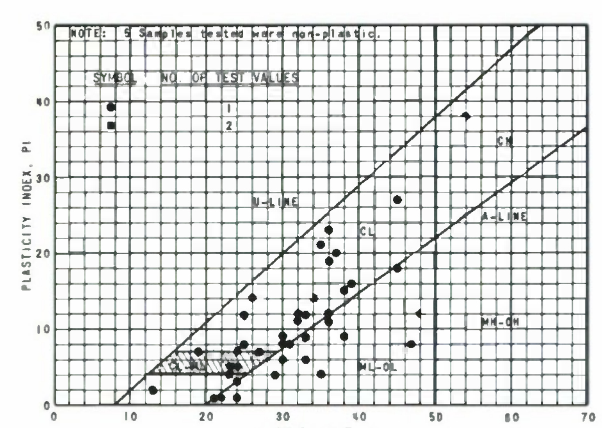
GRADATION



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

LETTER	SYMBOL	BORING NUMBER	DEPTH (Feet)	ATTERBERG LIMITS		G_s
				LL	PI	
A	●	7F-2	2.6 - 5.0	27	7	2.78
B	○	7F-7	14.4 - 18.2	-	-	2.80
C	△	7F-8	3.6 - 6.5	32	11	-
D	■	7F-8	18.2 - 20.7	-	NP	-
E	▼	7F-9	3.5 - 5.8	21	1	-
F	✱	7F-9	8.8 - 10.9	30	8	-
G	◇	7F-9	10.9 - 13.7	35	11	-
H	I	7F-10	12.5 - 14.8	46	12	-

ATTERBERG LIMITS



REVISION	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

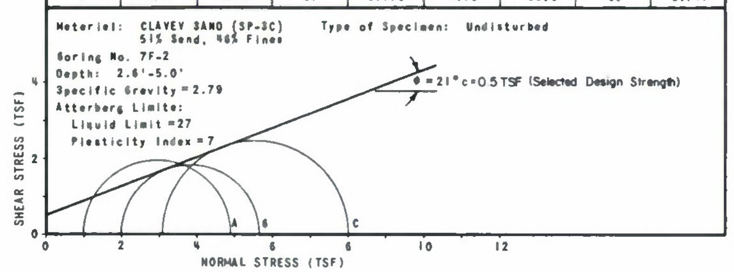
DRAWN BY: K. Wohl
CHECKED BY: D. Anderson
PREPARED BY: K. Swanson

REDBANK AND FANCHER CREEKS, CALIFORNIA
FANCHER CREEK
FANCHER CREEK DAM
SUMMARY OF TEST RESULTS
FOUNDATION

SUBMITTED: CHIEF, SOILS DESIGN SECTION
DATE APPROVED: 4/22/86
SCALE:
SPEC. No.
SHEET F 16 / 69
FILE No. SJ-11-20-11

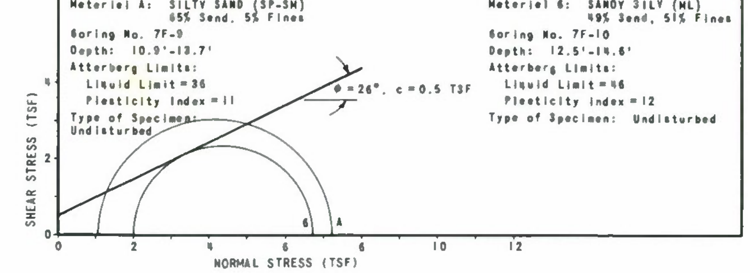
TRIAXIAL COMPRESSION TEST, CONSOLIDATED UNDRAINED (R)

TEST NO.	PROPERTIES							
	INITIAL				BEFORE SHEAR			
	WATER CONTENT (%)	DRY DENSITY (PCF)	SATURATION (%)	VOID RATIO	WATER CONTENT (%)	DRY DENSITY (PCF)	SATURATION (%)	VOID RATIO
A	16.7	66.0	66	0.756	25.6	100.2	66	0.736
B	24.3	93.4	76	0.665	26.6	65.3	100	0.626
C	16.4	96.3	67	0.770	26.0	100.0	96	0.741

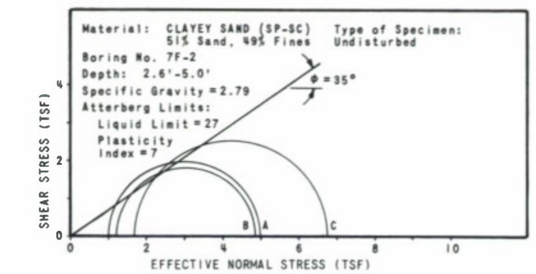


TRIAXIAL COMPRESSION TEST, CONSOLIDATED UNDRAINED (R)

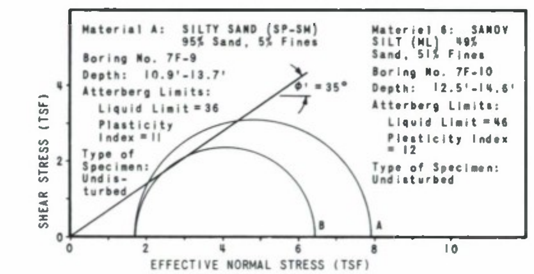
TEST NO.	PROPERTIES							
	INITIAL				BEFORE SHEAR			
	WATER CONTENT (%)	DRY DENSITY (PCF)	SATURATION (%)	VOID RATIO	WATER CONTENT (%)	DRY DENSITY (PCF)	SATURATION (%)	VOID RATIO
A	6.3	126.3	52	0.326	10.6	130.6	66	0.301
B	30.6	92.6	100	0.640	26.7	95.6	100	0.762



TRIAXIAL COMPRESSION TEST, EFFECTIVE STRENGTH (1)

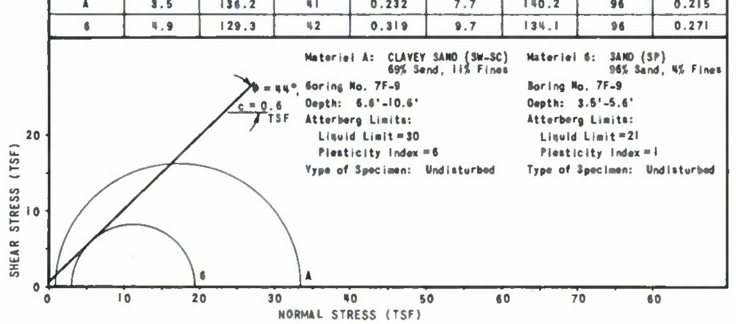


TRIAXIAL COMPRESSION TEST, EFFECTIVE STRENGTH (1)



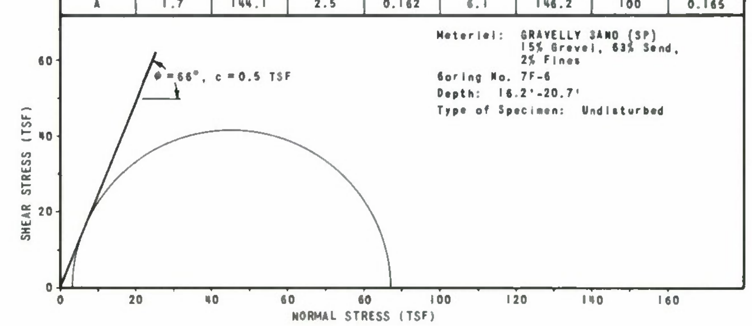
TRIAXIAL COMPRESSION TEST, CONSOLIDATED UNDRAINED (R)

TEST NO.	PROPERTIES							
	INITIAL				BEFORE SHEAR			
	WATER CONTENT (%)	DRY DENSITY (PCF)	SATURATION (%)	VOID RATIO	WATER CONTENT (%)	DRY DENSITY (PCF)	SATURATION (%)	VOID RATIO
A	3.5	136.2	41	0.232	7.7	140.2	96	0.215
B	4.9	129.3	42	0.319	9.7	134.1	96	0.271

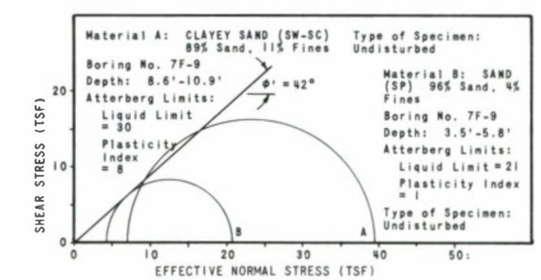


TRIAXIAL COMPRESSION TEST, CONSOLIDATED UNDRAINED (R)

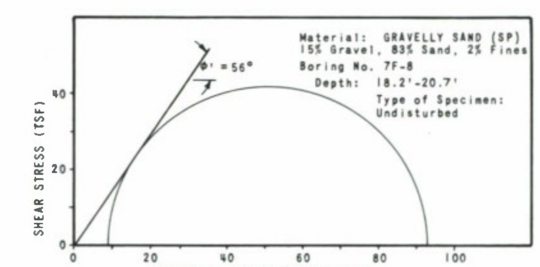
TEST NO.	PROPERTIES							
	INITIAL				BEFORE SHEAR			
	WATER CONTENT (%)	DRY DENSITY (PCF)	SATURATION (%)	VOID RATIO	WATER CONTENT (%)	DRY DENSITY (PCF)	SATURATION (%)	VOID RATIO
A	1.7	144.1	2.5	0.162	6.1	146.2	100	0.165



TRIAXIAL COMPRESSION TEST, EFFECTIVE STRENGTH (1)

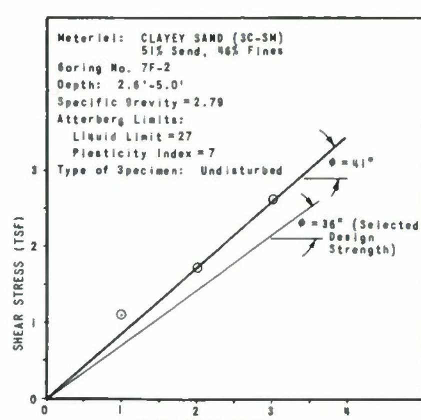


TRIAXIAL COMPRESSION TEST, EFFECTIVE STRENGTH (1)



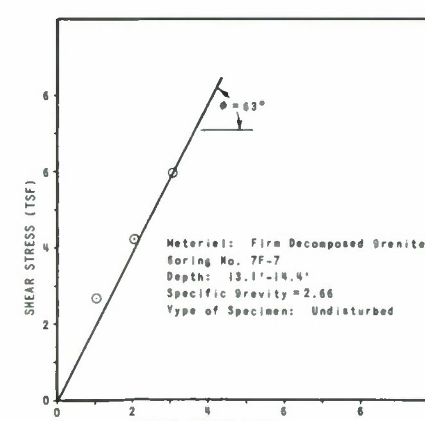
(1) Effective strengths were calculated from consolidated undrained triaxial compression tests with measured pore pressures.

DIRECT SHEAR TEST



	TEST NO.		A	B	C
INITIAL	Water Content (%)	W_o	17.4	16.6	16.9
	Void Ratio	e_o	0.675	0.665	0.660
	Saturation (%)	S_o	72	70	66
	Dry Density (PCF)	γ_d	104.0	104.5	103.6
	Void Ratio After Consolidation	e_c	0.661	0.638	0.650
FINAL	Water Content (%)	W_f	21.3	21.6	21.1
	Void Ratio	e_f	0.665	0.608	0.568
	Saturation (%)	S_f	61	100	100

DIRECT SHEAR TEST



	TEST NO.		A	B	C
INITIAL	Water Content (%)	W_o	5.0	4.5	5.5
	Void Ratio	e_o	0.309	0.265	0.233
	Saturation (%)	S_o	43	42	63
	Dry Density (PCF)	γ_d	126.8	129.2	134.6
	Void Ratio After Consolidation	e_c	0.266	0.250	0.179
FINAL	Water Content (%)	W_f	12.6	11.6	7.2
	Void Ratio	e_f	0.335	0.316	0.162
	Saturation (%)	S_f	100	99	100

REVISION	DATE	DESCRIPTION	BY	BY

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DRAWN BY: K. Wahl / N. Wilson
CHECKED BY: D. Anderson
PREPARED BY: K. Swanson

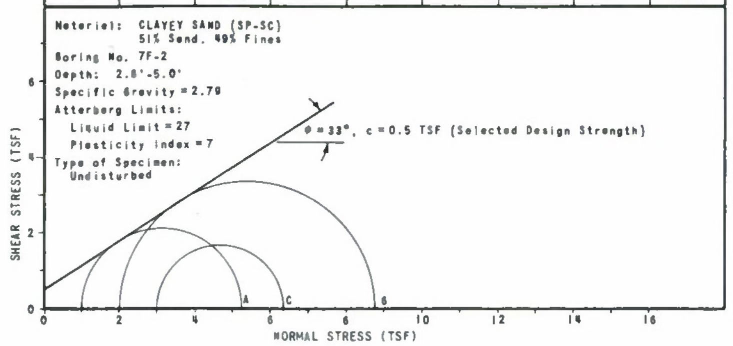
REDBANK AND FANCHER CREEKS, CALIFORNIA
FANCHER CREEK
FANCHER CREEK DAM
SUMMARY OF TEST RESULTS
FOUNDATION

SUBMITTED: [signature]
CHIEF, SOILS DESIGN SECTION
DATE APPROVED: 1/22/86
SCALE:
SPEC. No.
SHEET F 17 / 70
FILE No. SJ-11-20-11

ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING

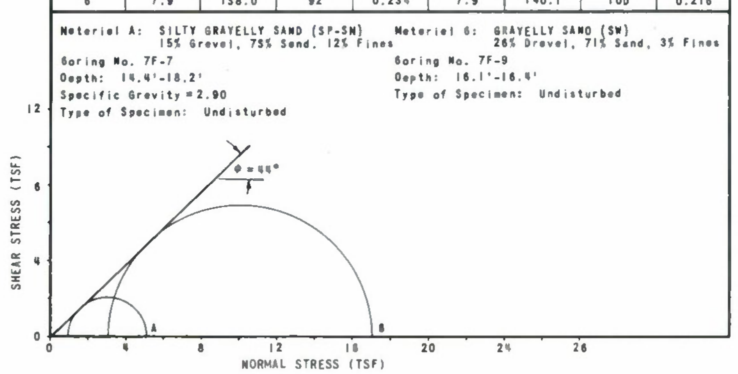
TRIAXIAL COMPRESSION TEST, UNCONSOLIDATED UNDRAINED (Q)

TEST NO.	PROPERTIES							
	INITIAL				BEFORE SHEAR			
	WATER CONTENT (%)	DRY DENSITY (PCF)	SATURATION (%)	VOID RATIO	WATER CONTENT (%)	DRY DENSITY (PCF)	SATURATION (%)	VOID RATIO
A	20.2	86.7	70	0.601	20.2	67.6	72	0.761
B	16.8	67.6	86	0.780	17.8	66.4	84	0.766
C	28.2	86.6	82	0.977	28.7	69.3	88	0.622



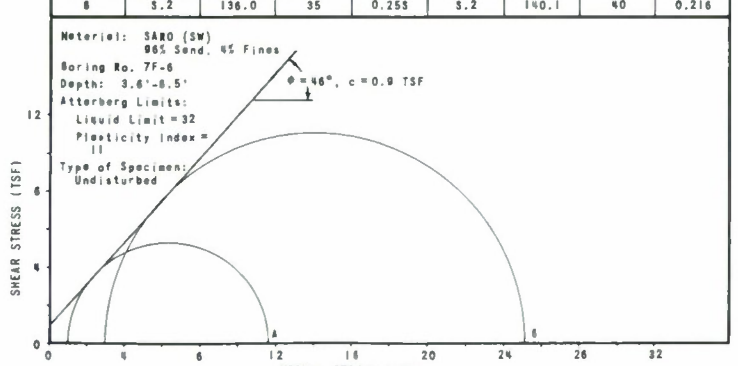
TRIAXIAL COMPRESSION TEST, UNCONSOLIDATED UNDRAINED (Q)

TEST NO.	PROPERTIES							
	INITIAL				BEFORE SHEAR			
	WATER CONTENT (%)	DRY DENSITY (PCF)	SATURATION (%)	VOID RATIO	WATER CONTENT (%)	DRY DENSITY (PCF)	SATURATION (%)	VOID RATIO
A	4.4	140.6	57	0.212	4.4	143.6	66	0.165
B	7.9	158.0	92	0.234	7.9	140.1	100	0.216

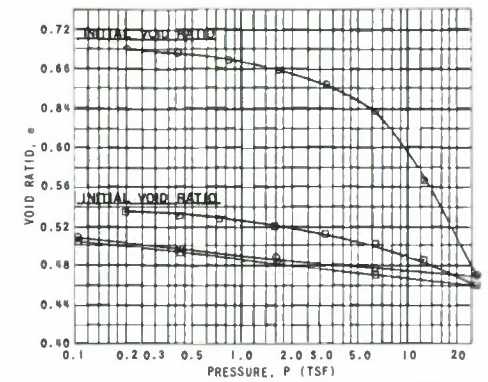


TRIAXIAL COMPRESSION TEST, UNCONSOLIDATED UNDRAINED (Q)

TEST NO.	PROPERTIES							
	INITIAL				BEFORE SHEAR			
	WATER CONTENT (%)	DRY DENSITY (PCF)	SATURATION (%)	VOID RATIO	WATER CONTENT (%)	DRY DENSITY (PCF)	SATURATION (%)	VOID RATIO
A	5.2	129.3	45	0.316	5.0	135.3	49	0.276
B	5.2	136.0	35	0.255	5.2	140.1	40	0.216

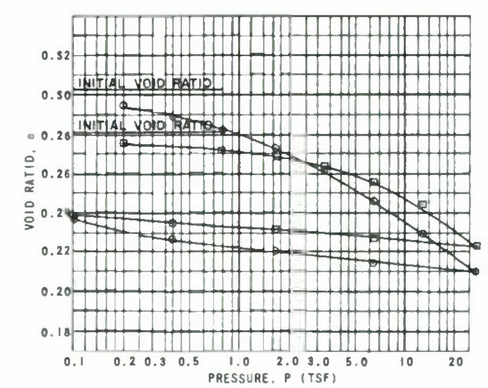


CONSOLIDATION



SYMBOL	MATERIAL	BORING NO.	DEPTH (Feet) FROM	DEPTH (Feet) TO	P_o (TSF)	P_c (TSF)	C_c	BEFORE TEST w_o (%)	BEFORE TEST e_o	BEFORE TEST S_o (%)	BEFORE TEST γ_d (PCF)	AFTER TEST w_f (%)	AFTER TEST e_f	AFTER TEST S_f (%)
—o—	CLAYEY SAND (SP-SC)	7F-2	2.6	5.0	0.2	-	--	16.6	0.712	74	101.7	17.6	0.516	100
—□—	SANDY CLAY (CL)	7F-1	10.0	13.3	0.6	-	--	18.8	0.542	65	112.9	18.3	0.519	96

CONSOLIDATION

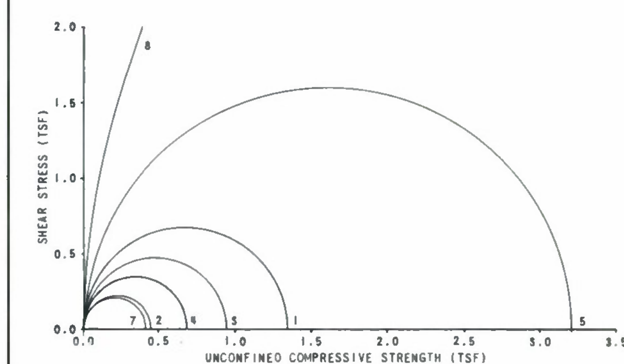


SYMBOL	MATERIAL	BORING NO.	DEPTH (Feet) FROM	DEPTH (Feet) TO	P_o (TSF)	P_c (TSF)	C_c	BEFORE TEST w_o (%)	BEFORE TEST e_o	BEFORE TEST S_o (%)	BEFORE TEST γ_d (PCF)	AFTER TEST w_f (%)	AFTER TEST e_f	AFTER TEST S_f (%)
—◇—	SILTY SAND (SW-SM)	7F-6	6.8	11.3	0.7	-	--	5.5	0.303	32	131.7	8.7	0.245	78
—□—	SILTY SAND (SM)	7F-7	10.4	15.1	0.8	-	--	6.1	0.261	61	136.3	8.9	0.241	100

UNCONFINED COMPRESSION TEST

CURVE NO.	BORING NO.	DEPTH (Feet)	CLASSIFICATION	GR (%)	SA (%)	FI (%)	LL	PI	W_o (%)	S_o (%)	DRY UNIT WEIGHT (PCF)	UNCONFINED COMPRESSIVE STRENGTH (TSF)
1	7F-1	0-2.5	SANDY CLAY (CL)	--	44	56	28	14	8.8	45	112.8	1.34
2	7F-5	7.0-8.7	CLAYEY SAND (SC)	--	87	13	36	15	8.4	56	125.8	0.44
3	7F-5	12.0-14.8	SAND (SP)	--	64	8	--	NP	4.7	37	155.8	0.63
4	7F-6	7.7-10.4	SILTY SAND** (SM-SW)	--	61	9	--	--	5.6	52	135.3	0.66
5	7F-6	8.8-11.3	SILTY SAND (SW-SM)	1	83	8	--	NP	5.0	40	141.7	3.21
6	7F-6	14.0-15.7	SAND (SP)	6	69	5	--	NP	4.5	62	137.6	11.27
7	7F-11	4.9-7.3	SANDY CLAY (CL)	--	59	81	--	--	16.1	66	96.6	0.41

**Specimen tested was a stratum from a sample of SANDY GRAVEL taken from the indicated depth.



REVISION	DATE	DESCRIPTION	BY	BY

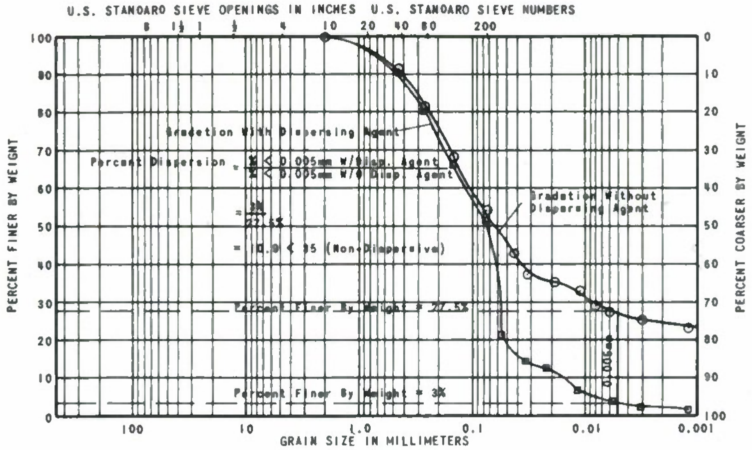
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DRAWN BY: K. Wahl
CHECKED BY: D. Anderson
PREPARED BY: K. Swanson

REDBANK AND FANCHER CREEKS, CALIFORNIA
FANCHER CREEK
FANCHER CREEK DAM
SUMMARY OF TEST RESULTS
FOUNDATION

SUBMITTED: [signature] CHIEF, SOILS DESIGN SECTION
DATE APPROVED: 4/22/80
SCALE:
SPEC. No.
SHEET F 15 / 71
FILE No. SJ-11-20-11

DISPERSION TEST

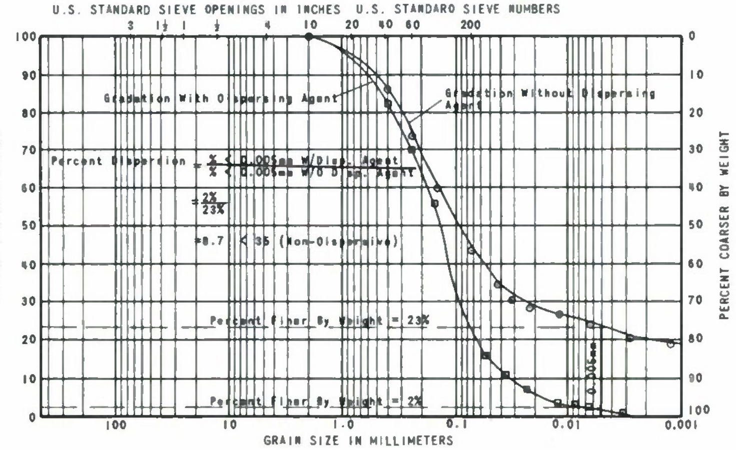


Dispersing Agent: Sodium Polyphosphate

COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

TRENCH NO.	DEPTH (Feet)	CLASSIFICATION	MOISTURE CONTENT	ATTERBERG LIMITS LL	PI
48-6	0-3.0	SANDY CLAY (CL)	-	50	18

DISPERSION TEST



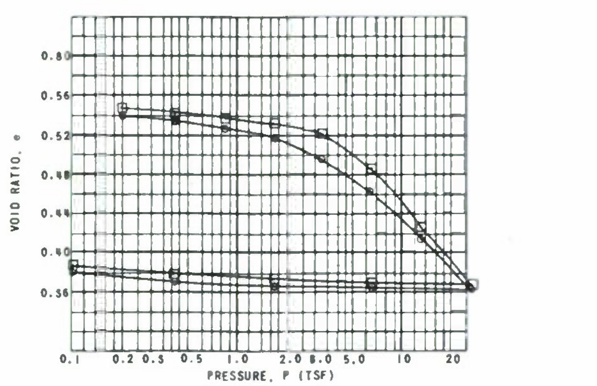
Dispersing Agent: Sodium Polyphosphate

COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

TRENCH NO.	DEPTH (Feet)	CLASSIFICATION	MOISTURE CONTENT	ATTERBERG LIMITS LL	PI
4H-11	0-2.7	CLAYEY SAND (SC)	-	23	8

CONSOLIDATION

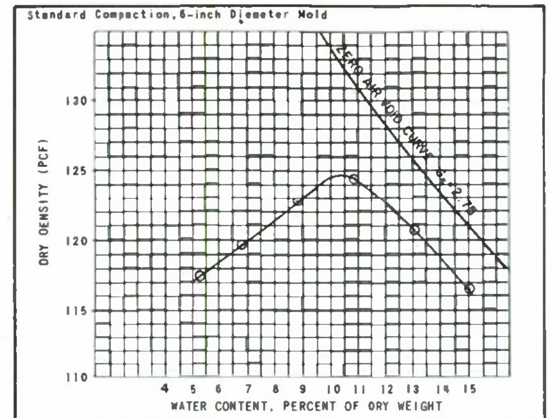
Sample: Composite A (Random Fill), Remolded to 90% Max Standard Density at Indicated Water Contents



SYMBOL	MATERIAL	PERCENT OF OPTIMUM WATER CONTENT	P_o (TSF)	P_c (TSF)	C_c	BEFORE TEST W_o (%)	e_o	S_o (%)	γ_d (PCF)	AFTER TEST W_f (%)	e_f	S_f (%)
●	CLAYEY SAND (SC-SM)	OPT + 2%	-	-	-	13.3	0.558	85	110.0	18.4	0.388	95
⊕	CLAYEY SAND (SC-SM)	OPT - 2%	-	-	-	9.2	0.556	46	110.3	12.6	0.397	89

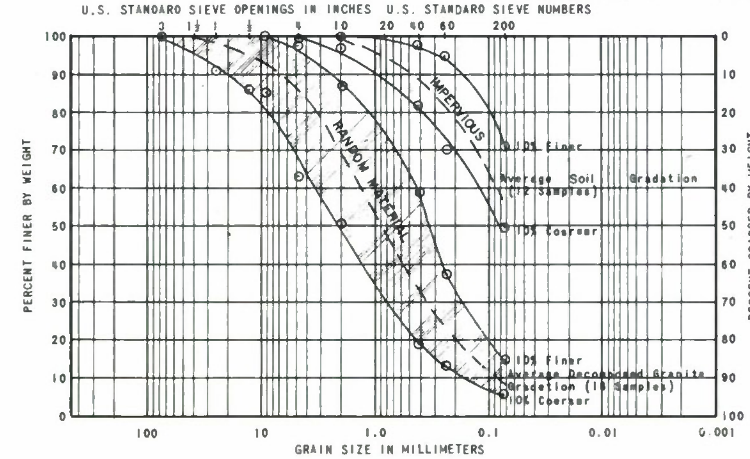
COMPACTION

Standard Compaction, 6-inch Diameter Mold



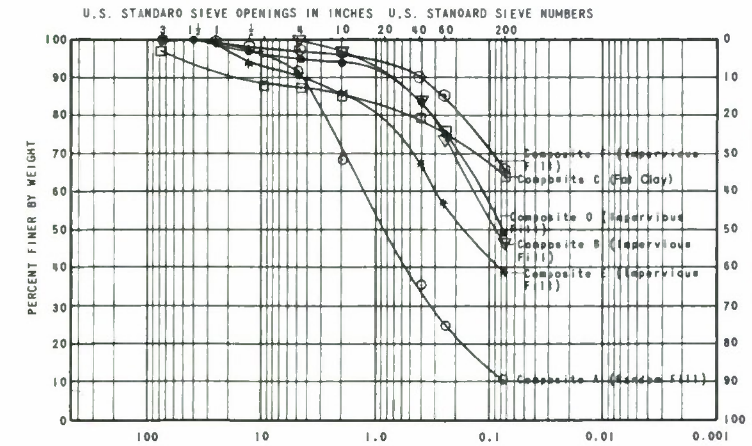
COMPOSITE NO.	MATERIAL	%>NO.4 / %>3/4"	SPECIFIC GRAVITY	ATTERBERG LIMITS LL	PI	SAMPLE CONTENT	OPTIMUM WATER CONTENT (%)	MAX. DRY DENSITY (PCF)
A	CLAYEY SAND (SC-SM)	8 / 2	2.75	40	19	8% Gravel 81% Sand 11% Fines	10.8	124.7

GRADATION



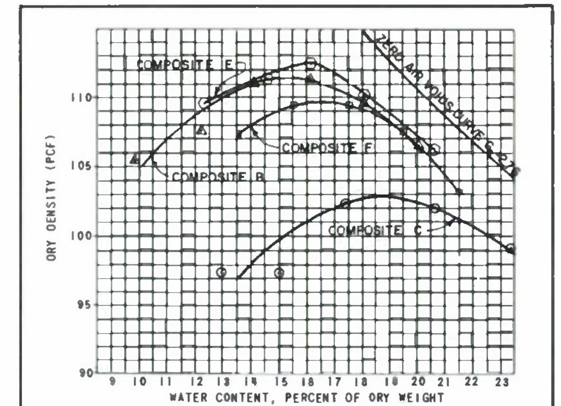
COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

GRADATION



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

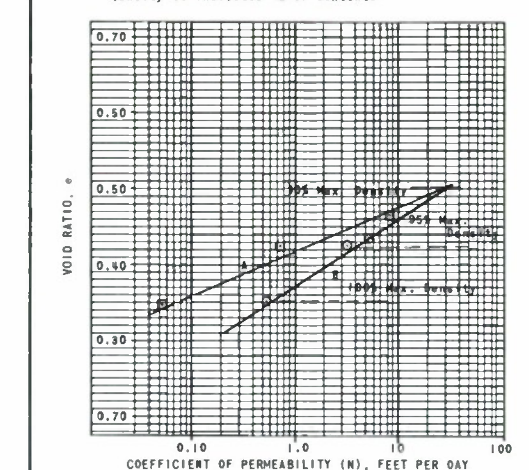
COMPACTION



COMPOSITE NO.	MATERIAL	%>NO.4 / %>3/4"	SPECIFIC GRAVITY	ATTERBERG LIMITS LL	PI	SAMPLE CONTENT	OPTIMUM WATER CONTENT (%)	MAX. DRY DENSITY (PCF)
B	CLAYEY SAND (SC)	0 / 0	2.75	32	18	53% Sand 47% Fines	15.4	111.5
C	SANDY CLAY (CH)	14 / 10	2.76	58	39	13% Gravel 23% Sand 64% Fines	18.8	103.0
E	CLAYEY SAND (SC)	10 / 4	2.82	37	18	10% GR. 51% SA. 59% FI	16.2	112.5
F	SANDY CLAY (CL)	3 / 2	2.80	30	11	3% GR. 32% SA. 65% FI	18.5	109.7

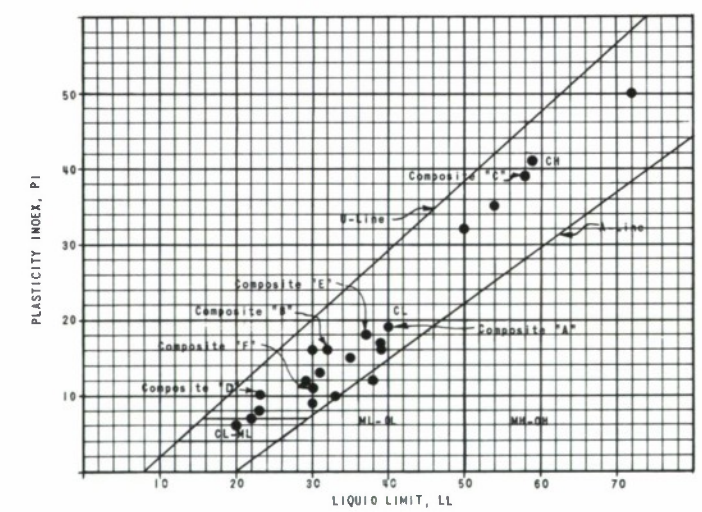
PERMEABILITY

Sample: Composite A, Remolded to Various Percents of Max. Standard Density at Indicated Water Contents



SYMBOL	MATERIAL	PERCENT OF OPTIMUM WATER CONTENT	CONDITION
A	CLAYEY SAND (SC-SM)	OPT + 2%	Remolded (8% Gravel, 81% Sand, 11% Fines)
B	CLAYEY SAND (SC-SM)	OPT - 2%	Remolded (8% Gravel, 81% Sand, 11% Fines)

ATTERBERG LIMITS



REVISION	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

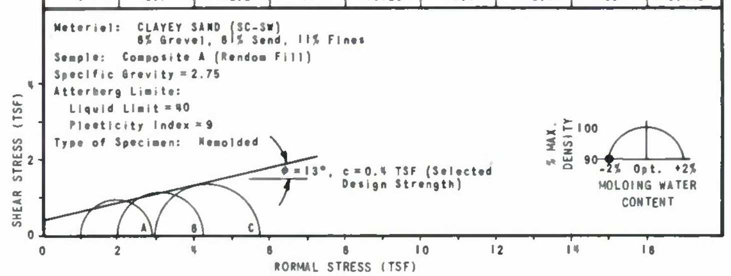
DRAWN BY: K. Wahl
CHECKED BY: D. Anderson
PREPARED BY: K. Swanson
SUBMITTED: Clark J. [signature], CHIEF, SOILS DESIGN SECTION

REDBANK AND FANCHER CREEKS, CALIFORNIA
FANCHER CREEK
FANCHER CREEK DAM
SUMMARY OF TEST RESULTS
BORROW AREA

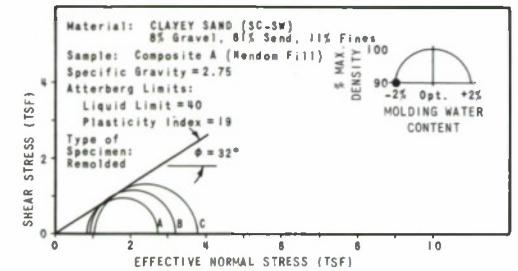
DATE APPROVED: 4/21/76
SHEET F 19 / 72
FILE No. SJ-11-20-11

TRIAXIAL COMPRESSION TEST, CONSOLIDATED UNDRAINED (R)

TEST NO.	INITIAL WATER CONTENT (%)	INITIAL DRY DENSITY (PCF)	INITIAL SATURATION (%)	INITIAL VOID RATIO	BEFORE SHEAR WATER CONTENT (%)	BEFORE SHEAR DRY DENSITY (PCF)	BEFORE SHEAR SATURATION (%)	BEFORE SHEAR VOID RATIO
A	8.7	112.0	45	0.533	17.4	115.3	98	0.489
B	8.1	112.9	43	0.521	16.5	117.3	98	0.464
C	9.7	112.2	51	0.529	15.5	118.5	98	0.449

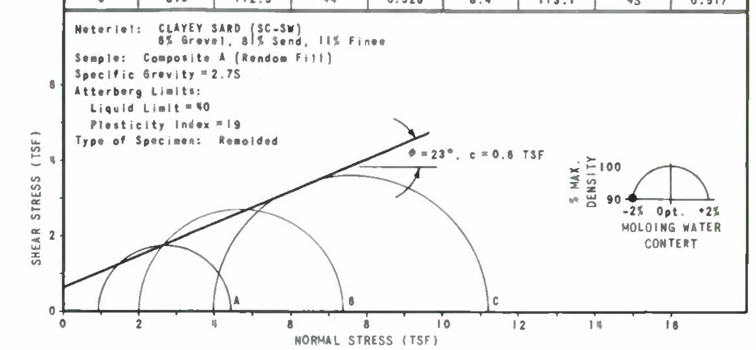


TRIAXIAL COMPRESSION TEST, EFFECTIVE STRENGTH (1)



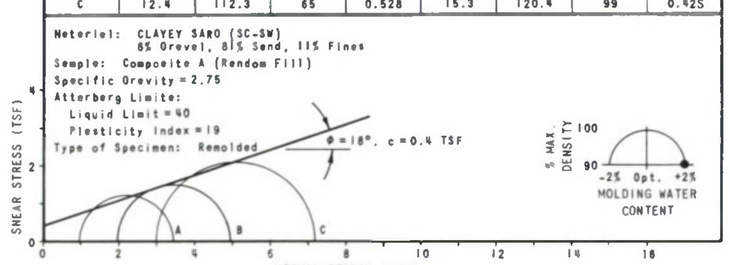
TRIAXIAL COMPRESSION TEST, UNCONSOLIDATED UNDRAINED (Q)

TEST NO.	INITIAL WATER CONTENT (%)	INITIAL DRY DENSITY (PCF)	INITIAL SATURATION (%)	INITIAL VOID RATIO	BEFORE SHEAR WATER CONTENT (%)	BEFORE SHEAR DRY DENSITY (PCF)	BEFORE SHEAR SATURATION (%)	BEFORE SHEAR VOID RATIO
A	8.2	112.8	43	0.520	8.2	113.1	44	0.517
B	8.2	112.8	43	0.524	8.3	113.1	44	0.517
C	8.5	112.3	44	0.528	8.4	113.1	45	0.517

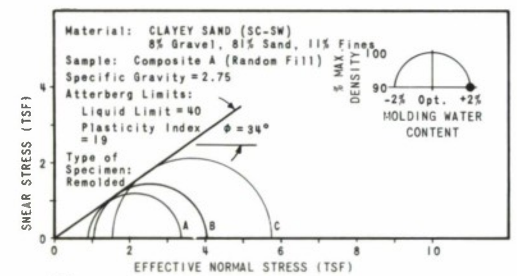


TRIAXIAL COMPRESSION TEST, CONSOLIDATED UNDRAINED (R)

TEST NO.	INITIAL WATER CONTENT (%)	INITIAL DRY DENSITY (PCF)	INITIAL SATURATION (%)	INITIAL VOID RATIO	BEFORE SHEAR WATER CONTENT (%)	BEFORE SHEAR DRY DENSITY (PCF)	BEFORE SHEAR SATURATION (%)	BEFORE SHEAR VOID RATIO
A	12.3	112.4	64	0.527	18.9	118.5	98	0.473
B	12.5	112.2	85	0.529	16.9	117.2	100	0.465
C	12.4	112.3	65	0.528	15.3	120.4	99	0.425



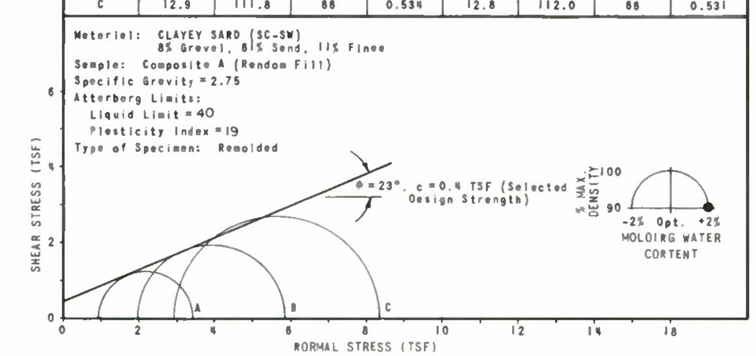
TRIAXIAL COMPRESSION TEST, EFFECTIVE STRENGTH (1)



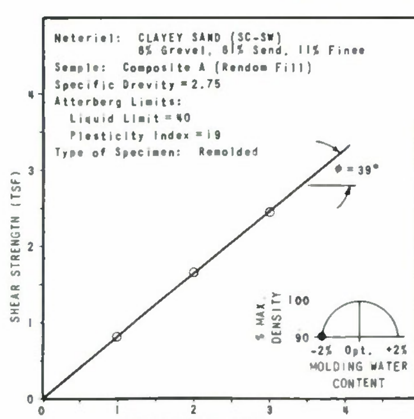
(1) Effective strengths were calculated from consolidated undrained triaxial compression tests with measured pore pressures.

TRIAXIAL COMPRESSION TEST, UNCONSOLIDATED UNDRAINED (Q)

TEST NO.	INITIAL WATER CONTENT (%)	INITIAL DRY DENSITY (PCF)	INITIAL SATURATION (%)	INITIAL VOID RATIO	BEFORE SHEAR WATER CONTENT (%)	BEFORE SHEAR DRY DENSITY (PCF)	BEFORE SHEAR SATURATION (%)	BEFORE SHEAR VOID RATIO
A	12.9	111.8	66	0.534	12.8	112.0	66	0.532
B	12.8	111.8	66	0.535	12.8	112.2	66	0.530
C	12.9	111.8	66	0.534	12.8	112.0	66	0.531

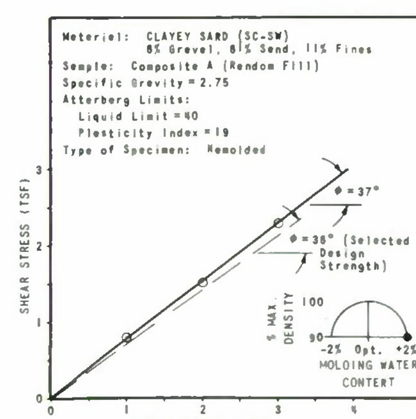


DIRECT SHEAR TEST



	TEST NO.		A	B	C
INITIAL	Water Content (%)	w_o	9.0	9.0	9.5
INITIAL	Void Ratio	e_o	0.555	0.554	0.59
INITIAL	Saturation (%)	S_o	45	45	47
INITIAL	Dry Density (PCF)	γ_d	110.3	110.4	110.0
	Void Ratio After Consolidation	e_c	0.543	0.437	0.530
FINAL	Water Content (%)	w_f	17.5	15.9	19.0
FINAL	Void Ratio	e_f	0.519	0.507	0.496
FINAL	Saturation (%)	S_f	93	96	99

DIRECT SHEAR TEST



	TEST NO.		A	B	C
INITIAL	Water Content (%)	w_o	13.5	13.5	12.9
INITIAL	Void Ratio	e_o	0.581	0.591	0.557
INITIAL	Saturation (%)	S_o	98	68	84
INITIAL	Dry Density (PCF)	γ_d	109.9	109.9	110.2
	Void Ratio After Consolidation	e_c	0.544	0.515	0.521
FINAL	Water Content (%)	w_f	14.9	13.9	18.1
FINAL	Void Ratio	e_f	0.538	0.519	0.495
FINAL	Saturation (%)	S_f	78	73	89

REVISION	DATE	DESCRIPTION	BY	BY

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

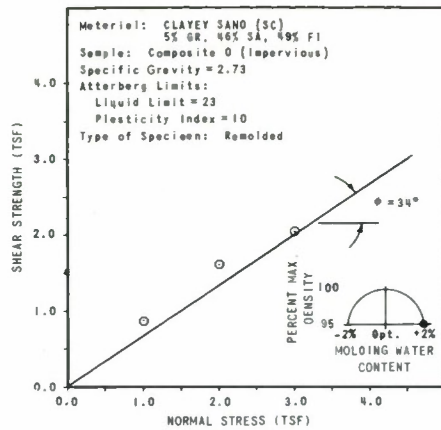
DRAWN BY: K. Wohl
CHECKED BY: D. Anderson
PREPARED BY: K. Swonson

REDBANK AND FANCHER CREEKS, CALIFORNIA
FANCHER CREEK

FANCHER CREEK DAM
SUMMARY OF TEST RESULTS
BORROW AREA

SUBMITTED: [signature] CHIEF, SOILS DESIGN SECTION
DATE APPROVED: 4/22/86
SCALE:
SPEC. No.
SHEET F 20 / 73
FILE No. SJ-11-20-11

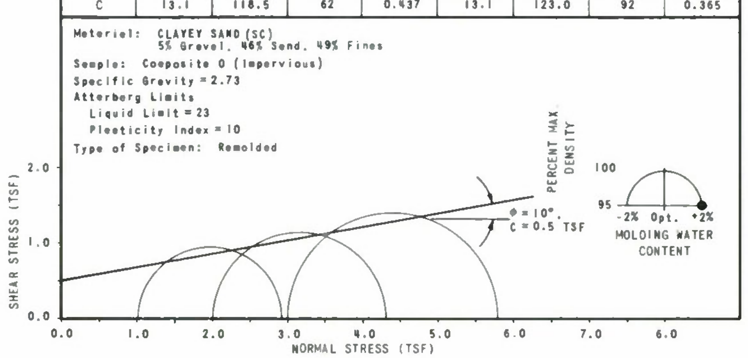
DIRECT SHEAR TEST



	TEST NO.		A	B	C
INITIAL	Water Content (%)	Wo	12.7	12.5	13.1
	Void Ratio	eo	0.432	0.429	0.435
	Saturation (%)	So	60	80	62
	Dry Density (PCF)	γd	119.0	119.2	118.7
	Void Ratio After Consolidation	ec	0.406	0.399	0.435
FINAL	Water Content	Wf	13.7	12.7	12.0
	Void Ratio	ef	0.377	0.345	0.339
	Saturation	Sf	99	100	97

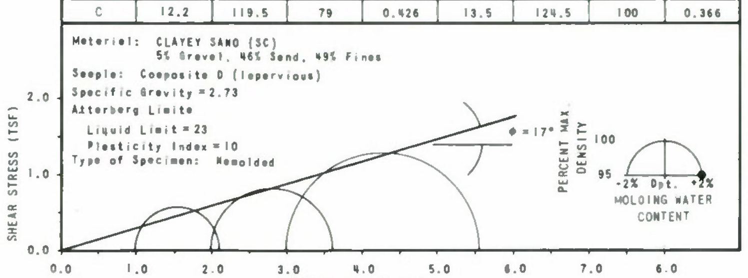
TRIAXIAL COMPRESSION TEST, UNCONSOLIDATED UNDRAINED (Q)

TEST NO.	INITIAL WATER CONTENT (%)	INITIAL DRY DENSITY (PCF)	INITIAL SATURATION (%)	INITIAL VOID RATIO	BEFORE SHEAR WATER CONTENT (%)	BEFORE SHEAR DRY DENSITY (PCF)	BEFORE SHEAR SATURATION (%)	BEFORE SHEAR VOID RATIO
A	12.9	118.6	81	0.436	12.9	120.6	85	0.412
B	13.2	118.4	62	0.439	13.2	121.6	91	0.399
C	13.1	118.5	62	0.437	13.1	123.0	92	0.365

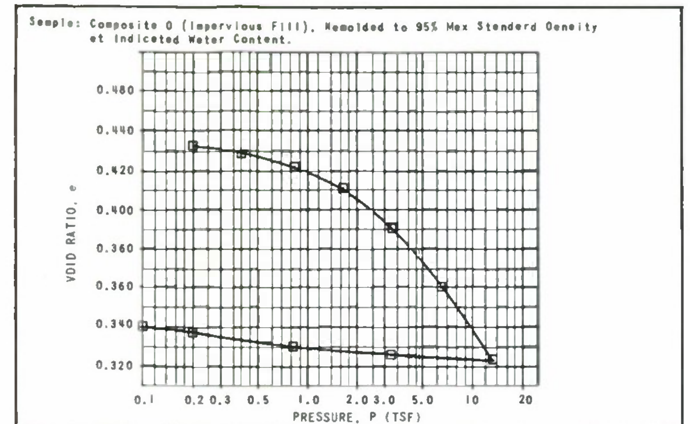


TRIAXIAL COMPRESSION TEST, CONSOLIDATED UNDRAINED (R)

TEST NO.	INITIAL WATER CONTENT (%)	INITIAL DRY DENSITY (PCF)	INITIAL SATURATION (%)	INITIAL VOID RATIO	BEFORE SHEAR WATER CONTENT (%)	BEFORE SHEAR DRY DENSITY (PCF)	BEFORE SHEAR SATURATION (%)	BEFORE SHEAR VOID RATIO
A	12.6	116.9	61	0.433	15.3	120.0	100	0.420
B	15.0	118.6	61	0.436	14.6	122.0	100	0.397
C	12.2	119.5	79	0.426	13.5	124.5	100	0.366

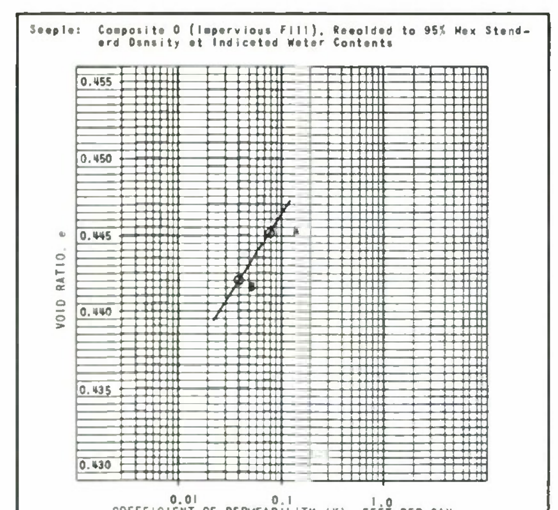


CONSOLIDATION



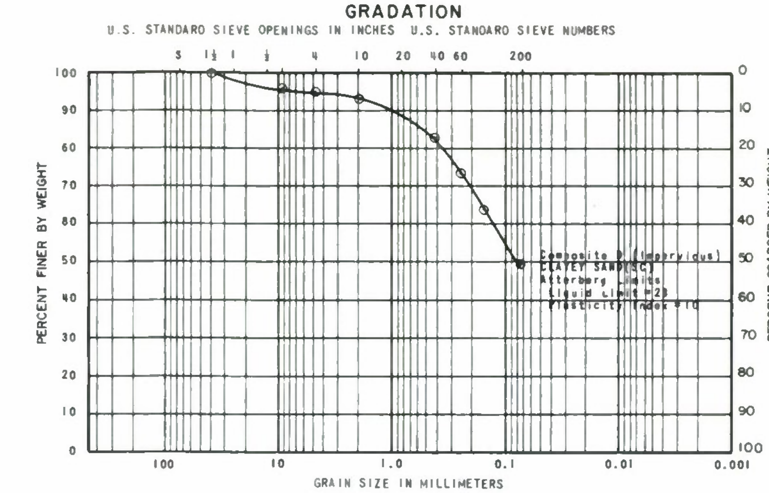
SYMBOL	MATERIAL	PERCENT OF OPTIMUM WATER CONTENT	P_o (TSF)	P_c (TSF)	C_c	BEFORE TEST W_o (%)	BEFORE TEST e_o	BEFORE TEST S_o (%)	BEFORE TEST γ_d (PCF)	AFTER TEST W_f (%)	AFTER TEST e_c	AFTER TEST S_f (%)
⊟	CLAYEY SAND (SC)	OPT + 2%	-	-	-	13.2	0.436	62	116.4	12.4	0.352	96

PERMEABILITY



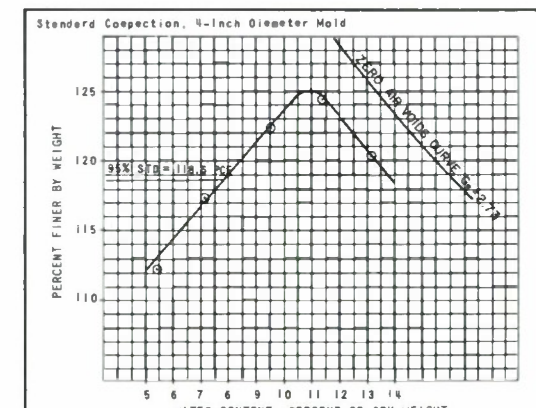
SYMBOL	MATERIAL	PERCENT OF OPTIMUM WATER CONTENT	CONDITION
A	CLAYEY SAND (SC)	OPT -2%	REMOLDED (5% GR, 46% SA, 49% FI)
B	CLAYEY SAND (SC)	OPT +2%	REMOLDED (5% GR, 46% SA, 49% FI)

GRADATION



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

COMPACTION



COMPOSITE NO	MATERIAL	%NO 4 / %>3/4"	SPECIFIC GRAVITY	ATTERBERG LIMITS LL	ATTERBERG LIMITS PI	SAMPLE CONTENT	OPTIMUM WATER CONTENT (%)	MAX DRY DENSITY (PCF)
O	CLAYEY SAND (%)	5 / 2	2.73	23	10	5% GR 46% SA 49% FI	11.0	124.6

REVISION	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DRAWN BY: K. Wahl
CHECKED BY: D. Anderson
PREPARED BY: K. Swanson
SUBMITTED: CHIEF, SOILS DESIGN SECTION

REDBANK AND FANCHER CREEKS, CALIFORNIA
FANCHER CREEK
FANCHER CREEK DAM
SUMMARY OF TEST RESULTS
BORROW AREA

DATE APPROVED: 4/22/86
SCALE:
SPEC. No.
SHEET F21 / 74
FILE No. SJ-11-20-11

Slice No.	Segment No.	Segment Area (SqFt)	Moist Unit Weight (PCF)	Segment Weight (Kips)	Slice Weight (Kips)	Base Length of Slice (Ft)	C/L	C/L / F.S.	ϕ_D*
1	1a	3.4	131.0	0.5	0.5	4.0	3.2	1.5	11.4
2	2a	25.3	131.0	3.3	8.5	12.6	12.6	6.0	4.8
2	2b	39.6	131.0	5.2					
3	3a	174.4	131.0	22.9	22.9	14.7	11.8	4.5	11.4
4	4a	191.9	131.0	25.1	25.1	12.2	9.8	3.7	11.4
5	5a	203.3	131.0	26.6	26.6	11.4	9.1	3.5	11.4
6	6a	201.1	131.0	26.3	26.3	10.9	8.7	3.3	11.4
7	7a	198.4	131.0	26.0	26.0	11.1	8.9	3.4	11.4
8	8a	147.5	131.0	19.3	20.6	9.8	-	-	19.1
8	8b	10.9	115.0	1.3					
9	9a	105.4	131.0	13.8	17.0	10.0	-	-	19.1
9	9b	27.6	115.0	3.2					
10	10a	57.0	131.0	7.5	11.6	10.2	-	-	19.1
10	10b	35.9	115.0	4.1					
11	11a	9.7	131.0	1.3	5.2	12.6	-	-	19.1
11	11b	33.5	115.0	3.9					

$^*\phi_D = \text{Arc tan } \frac{\tan \phi}{F.S.}$

ADOPTED DESIGN DATA				
Material	Q Strength ϕ Degree	Q Strength Cohesion Kips/Sq Ft	Unit Weight PCF γ_m	Unit Weight PCF γ_s
Random Fill	23	0.8	131.0	137.8
Impervious Fill	10	1.0	131.6	137.6
Drainage Fill	36	0	115.0*	130.0
Foundation Soil	33	1.0	129.3	132.2

*See Note 4

FIGURE 3 Design Data

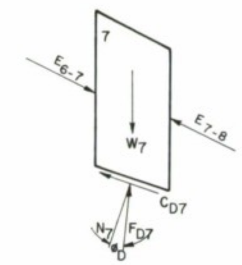
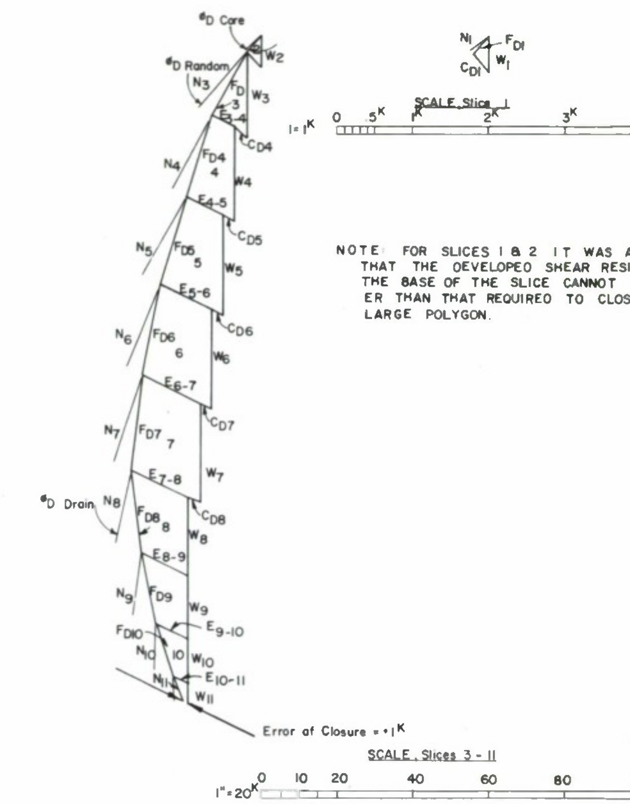


FIGURE 4 Typical Slice



NOTE: FOR SLICES 1 & 2 IT WAS ASSUMED THAT THE DEVELOPED SHEAR RESISTANCE ON THE BASE OF THE SLICE CANNOT BE GREATER THAN THAT REQUIRED TO CLOSE THE LARGE POLYGON.

FIGURE 5 - Composite Force Polygon For Trial F.S. = 2.1

NOTES:

1. End of Construction analysis for finite slice method performed by Harris Computer System using program no 741X6L2040 developed by St Paul District, Corp of Engineers.
2. The computer solution for the critical arc shown was a factor of safety of 2.1. The manual check of this solution agreed closely.
3. The seismic condition assumes a horizontal force of 0.10 times the slice weight.
4. Drainage fill was assumed to be dry if located above phreatic surface.

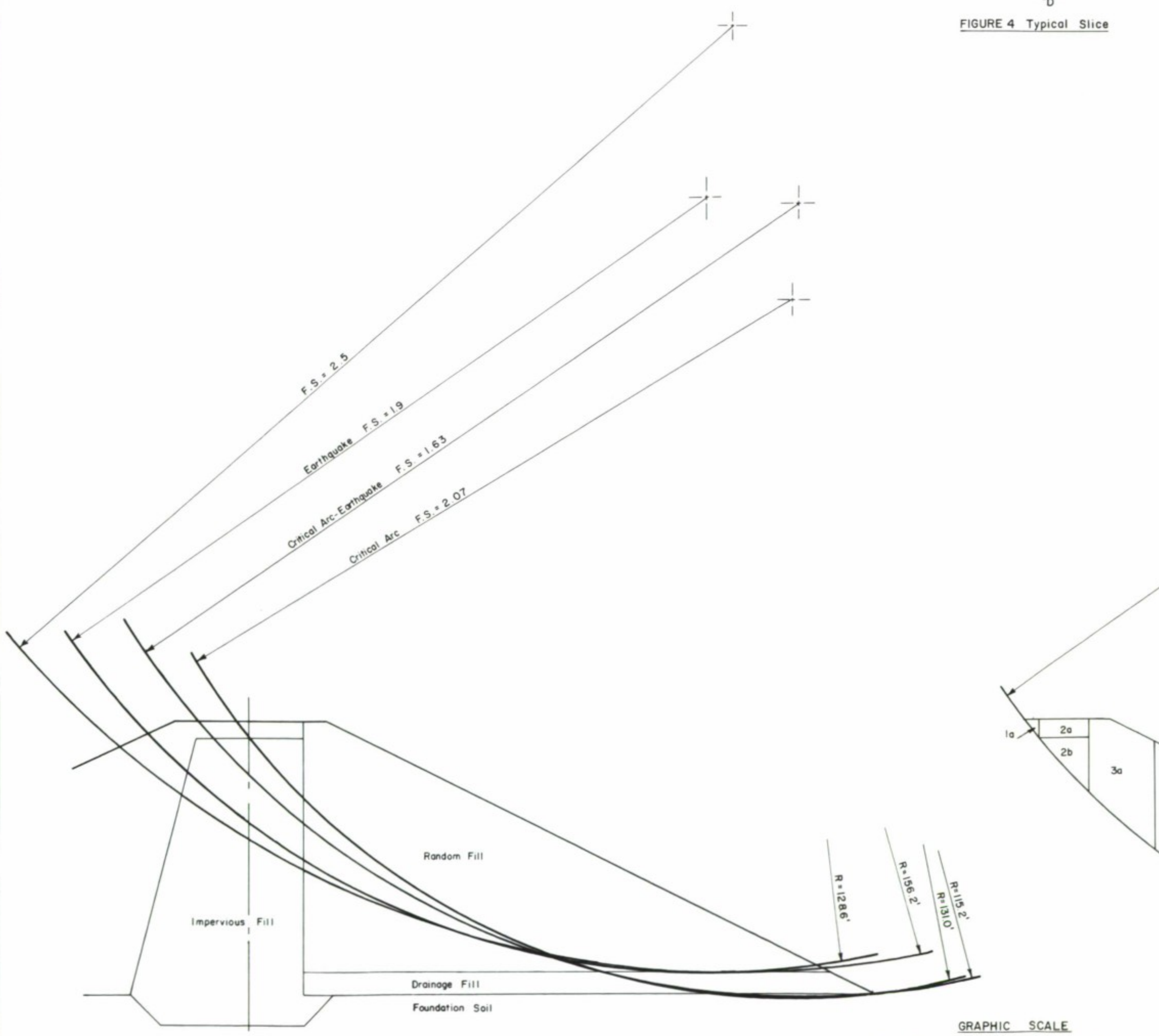


FIGURE 1 Embankment Section

GRAPHIC SCALE

1" = 10' 0 5' 10' 20' 30' 40' 50'

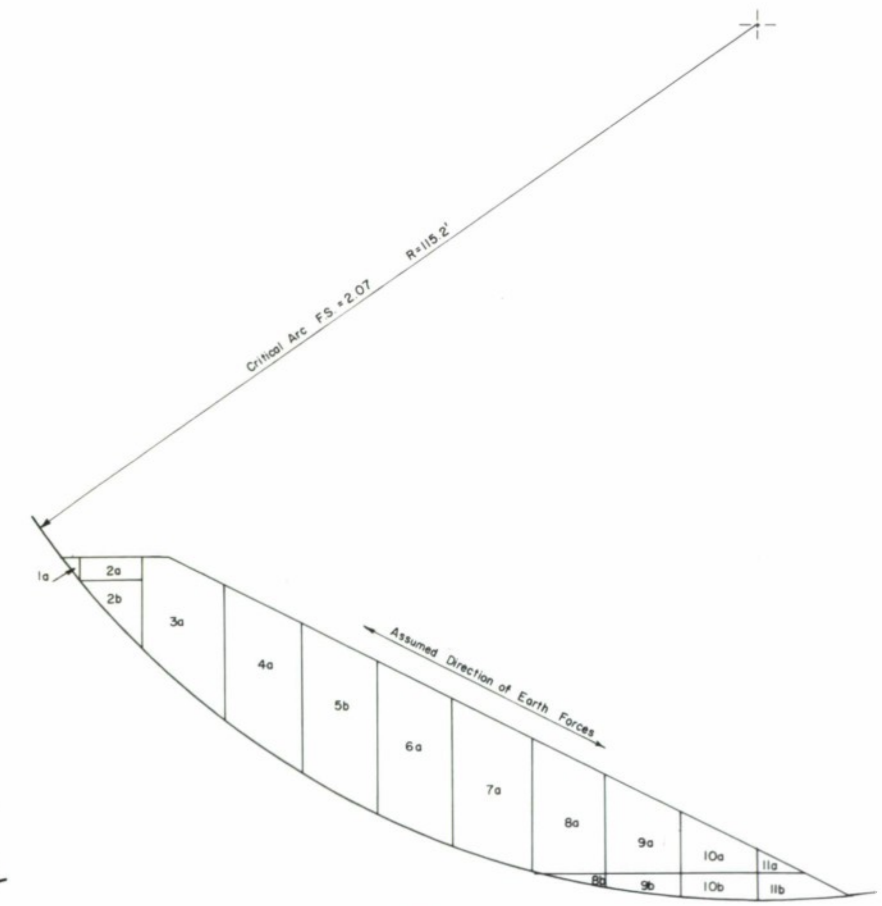


FIGURE 2 Critical Arc

REVISION	DATE	DESCRIPTION	BY	BY

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DESIGNED: K. Swanson
DRAWN: K. Wahl
CHECKED: D. Anderson
SUBMITTED: CHIEF, SOILS DESIGN SECTION
DATE APPROVED:

REDBANK AND FANCHER CREEKS, CALIFORNIA
FANCHER CREEK

FANCHER CREEK DAM
STABILITY ANALYSIS
END OF CONSTRUCTION

SCALE: | SPEC. No.
SHEET F 22 / 75 | FILE No. SJ-11-20-11

Materials	"S" Strength		"$\frac{R+S}{2}$" Strength		Unit Weight (PCF)	
	ø Degree	Cohesion Kips/SqFt	ø Degree	Cohesion Kips/Sq Ft	γ_m	γ_s
Random Fill	36	0	24.5	0.46	131.0	137.8
Impervious Fill	34	0	25.5	0	131.6	137.6
Drainage Fill	34	0	34.0	0	115.0*	130.0
Foundation	36	0	28.5	0.55	129.3	132.2

ADOPTED DESIGN DATA

* See Note 6

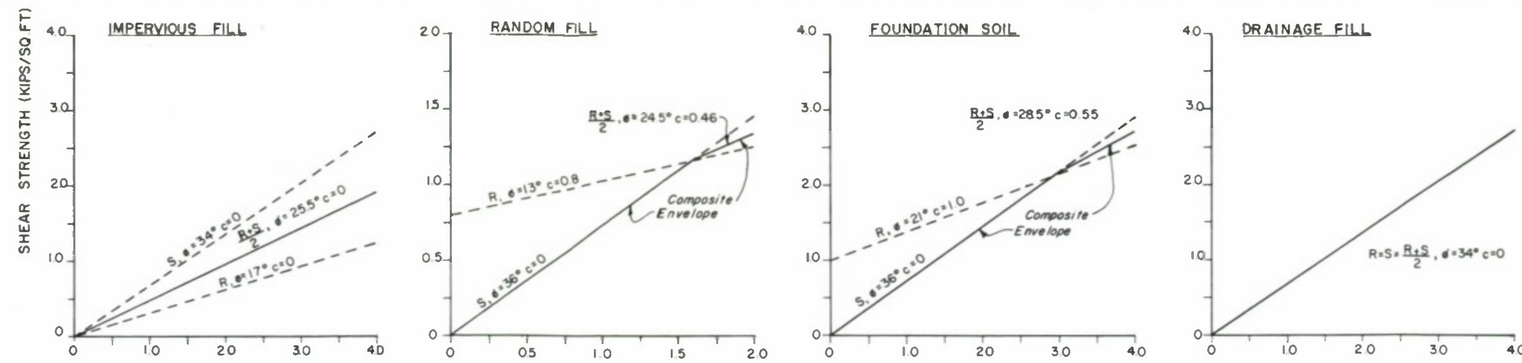


FIGURE 3 - Composite Envelopes

Slice No.	Base Length Δl (Ft)	Segment No.	Segment Area (Sq Ft)	Moist Unit Weight (PCF)	Saturated Unit Weight (PCF)	Segment Weight (Kips)	Slice Weight (Kips)	Piezometric Height at Base of Slice (Ft) Left	Piezometric Height at Base of Slice (Ft) Right	Water Pressure on Base (KSF) Left	Water Pressure on Base (KSF) Right	U_L (Kips)	U_R (Kips)	$(U_L - U_R)$ (Kips)	Uplift U_B (Kips)	$ø_D$	c_D
1	6.4	1	10.9	131.0	-	1.4	1.4	-	-	-	-	-	-	-	-	23.1	0
2	23.8	2a	66.9	131.0	-	8.8	30.7	-	-	-	-	-	-	-	-	15.7	0
2	23.8	2b	166.7	131.6	-	21.9											
3	17.4	3a	307.6	131.0	-	40.3	43.5	0	2.5	0.2	0.2	0	0.2	-0.2	1.7	15.0	0.3
3	17.4	3b	23.5	-	137.8	3.2											
4	15.7	4a	301.7	131.0	-	39.5	45.4	2.5	3.1	0.2	0.2	0.2	0.3	-0.1	3.1	15.0	0.3
4	15.7	4b	42.9	-	137.8	5.9											
5	13.2	5a	264.2	131.0	-	34.6	39.8	3.1	2.8	0.2	0.2	0.3	0.2	0.1	2.6	15.0	0.3
5	13.2	5b	37.5	-	137.8	5.2											
6	11.3	6a	214.7	131.0	-	28.1	31.3	2.8	3.0	0.2	0.2	0.2	0.3	-0.1	2.3	23.1	0
6	11.3	6b	7.3	-	137.8	1.0											
6	11.3	6c	17.1	-	130.9	2.2											
7	13.7	7a	200.1	131.0	-	26.3	34.8	3.0	5.8	0.2	0.4	0.3	0.1	0.2	4.1	17.7	0.3
7	13.7	7b	5.2	115.0	-	0.6											
7	13.7	7c	39.9	-	130.9	5.2											
7	13.7	7d	20.7	-	132.2	2.7											
8	14.6	8a	123.1	131.0	-	16.1	29.9	5.8	7.4	0.4	0.5	1.0	1.7	-0.7	6.6	23.1	0
8	14.6	8b	12.9	115.0	-	1.5											
8	14.6	8c	37.7	-	130.9	4.9											
8	14.6	8d	56.2	-	132.2	7.4											
9	18.0	9a	25.8	131.0	-	3.4	22.0	7.4	5.4	0.5	0.3	1.7	0.8	0.9	7.2	23.1	0
9	18.0	9b	15.8	115.0	-	1.8											
9	18.0	9c	34.7	-	130.9	4.5											
9	18.0	9d	92.9	-	132.2	12.3											
10	16.3	10	80.6	-	132.2	10.7	10.7	5.4	4.0	0.3	0.2	0.8	0.4	0.4	5.7	23.1	0
11	22.5	11	49.9	-	132.2	6.6	6.6	4.0	0	0.2	0	0.8	0	0.8	2.3	23.1	0

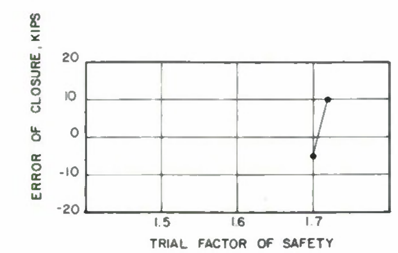


FIGURE 7 Trial Factor of Safety vs. Error of Closure

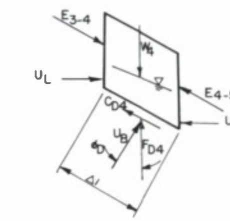


FIGURE 4 - Typical Slice

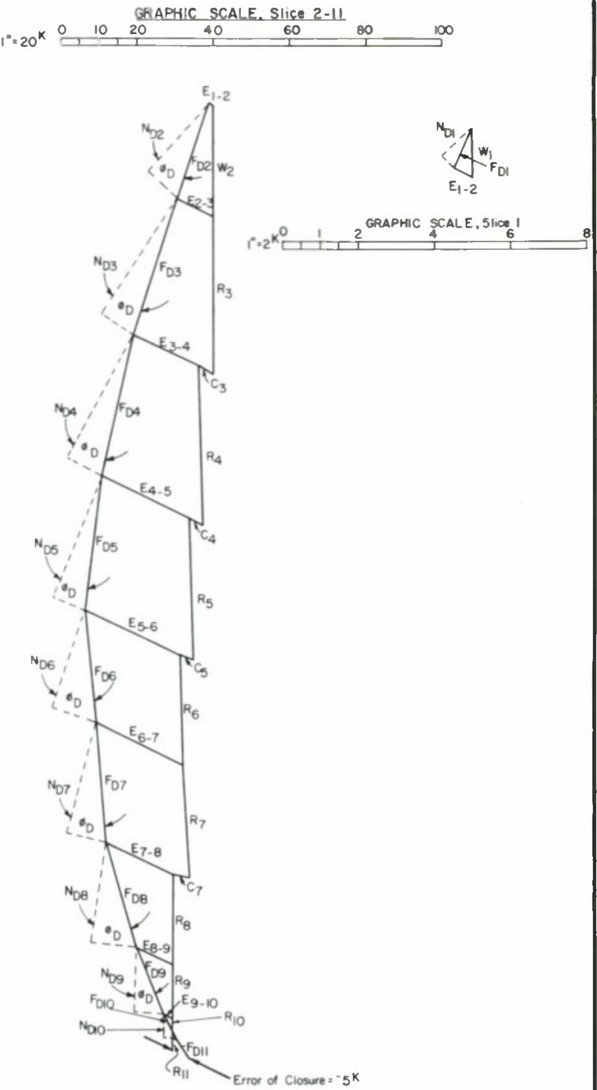


FIGURE 6 - Composite Force Polygon For Trial F.S. 1.7

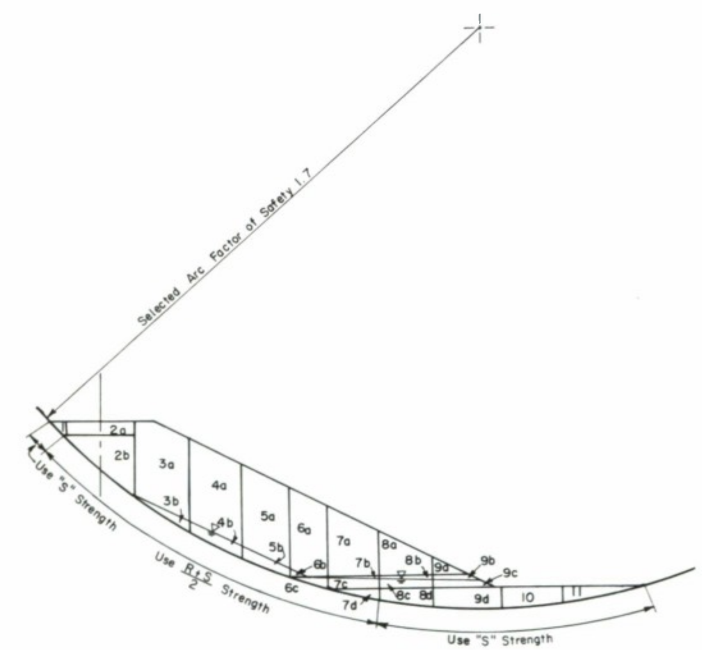


FIGURE 2 - Selected Arc

GRAPHIC SCALE

1" = 20'

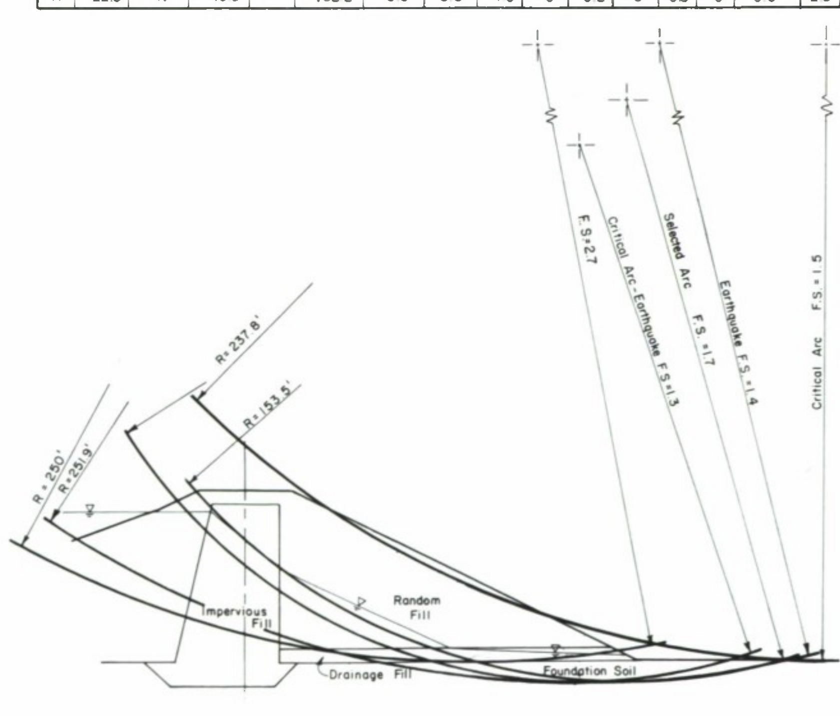


FIGURE 1 - Embankment Section

GRAPHIC SCALE

1" = 20'

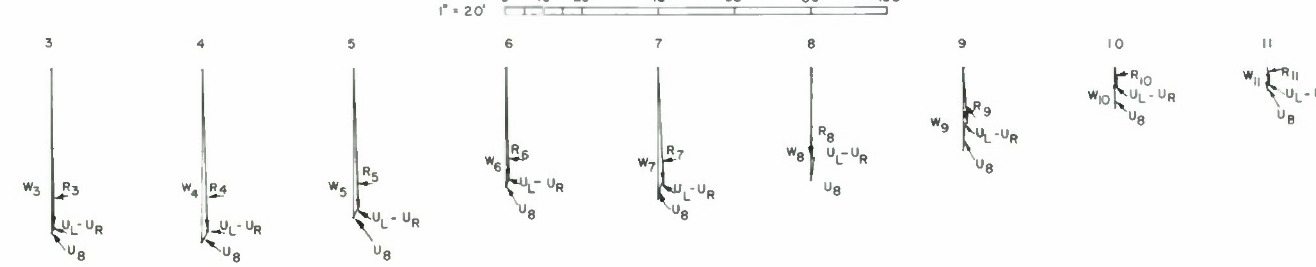


FIGURE 5 - Resultant of Weight and Water Forces on Slice

NOTES:

1. Steady Seepage analysis for finite slice method performed by Harris Computer System using program no. 741X6L2040 developed by St Paul District, Corps of Engineers.
2. The computer solution factor of safety for the arc shown was 1.7. The manual check of this arc was a factor safety of 1.66.
3. The seismic condition assumes a horizontal force at 0.10 times the slice weight.
4. The shear strength used for each slice in the force polygon was selected by trial. If the normal force N_O determined using the S strength exceeded 1.6 KSF times the base length of the slice, the $\frac{R+S}{2}$ strength was used. This applies to the Random Fill, slices 3-5.
5. The arc shown, though not the critical arc, was chosen due to the significant nature of the failure. Various areas, typifying the range of failure surfaces, are shown in figure 1. Minimum factors of safety of approximately 1.5 occur as the failure arcs approaches the surface of the embankment.
6. Drainage fill was assumed to be dry if located above phreatic surface.

REVISION	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DESIGNED: K. Swanson
DRAWN: K. Wahl
CHECKED: D. Anderson
SUBMITTED: CHIEF, SOILS DESIGN SECTION

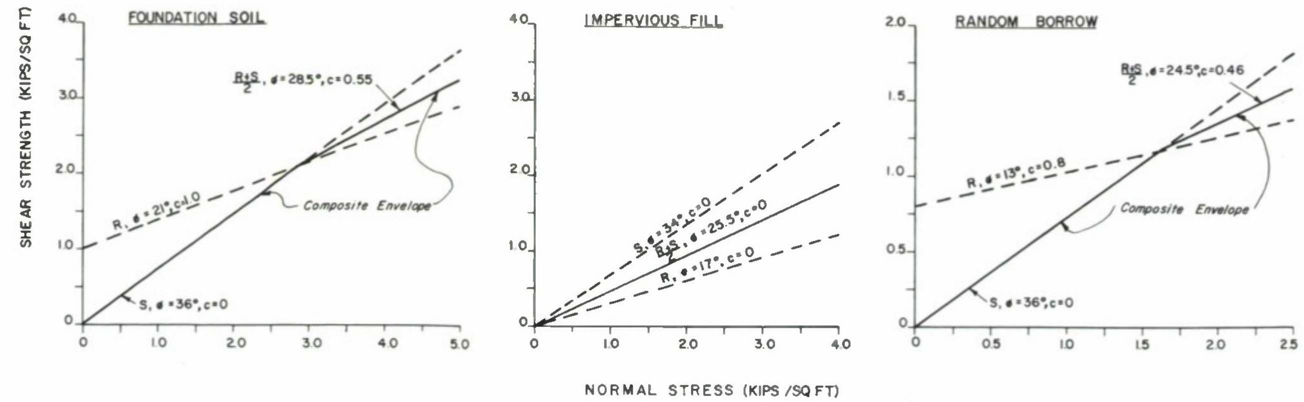
REDBANK AND FANCHER CREEKS, CALIFORNIA
FANCHER CREEK
FANCHER CREEK DAM
STABILITY ANALYSIS
STEADY SEEPAGE

DATE APPROVED: 1/21/86
SHEET F 23 / 76
SJ-11-20-11

ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING

Slice No.	Segment No.	Area of Segment (Sq Ft)	γ_m	γ_b	Segment Weight (Kips)	Slice Weight (Kips)	Δl	ϕ_D*
1	1	72.4	131.0	-	9.5	9.5	20.0	19.08
2	2a	104.8	131.0	-	13.7	15.4	16.6	19.08
2	2b	22.0	-	75.4	1.7			
3	3a	30.8	131.0	-	4.0	12.4	15.5	19.08
3	3b	111.9	-	75.4	8.4			
4	4	191.7	-	75.4	14.4	14.4	18.3	19.08
5	5	191.7	-	75.4	14.4	14.4	17.9	19.08
6	6	161.6	-	75.4	12.2	12.2	16.6	19.08
7	7	121.8	-	75.4	9.2	9.2	16.4	19.08
8	8	74.4	-	75.4	5.6	5.6	23.6	19.08

* $\phi_D = \text{Arc tan} \dfrac{\tan \phi}{F.S.}$



Material	"S" Strength		"R+S"/2 Strength		Unit Weight (P.C.F.)	
	ϕ Degree	Cohesion (Kips/Sqft)	ϕ Degree	Cohesion (Kips/SqFt)	γ_m	γ_b
Impervious Fill	34	0	25.5	0	131.6	75.2
Random Fill	36	0	24.5	0.46	131.0	75.4
Foundation Soil	36	0	28.5	0.55	129.3	69.9

ADOPTED DESIGN DATA

FIGURE 3 - Composite Strength Envelopes

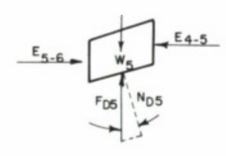


FIGURE 4 - Typical Slice

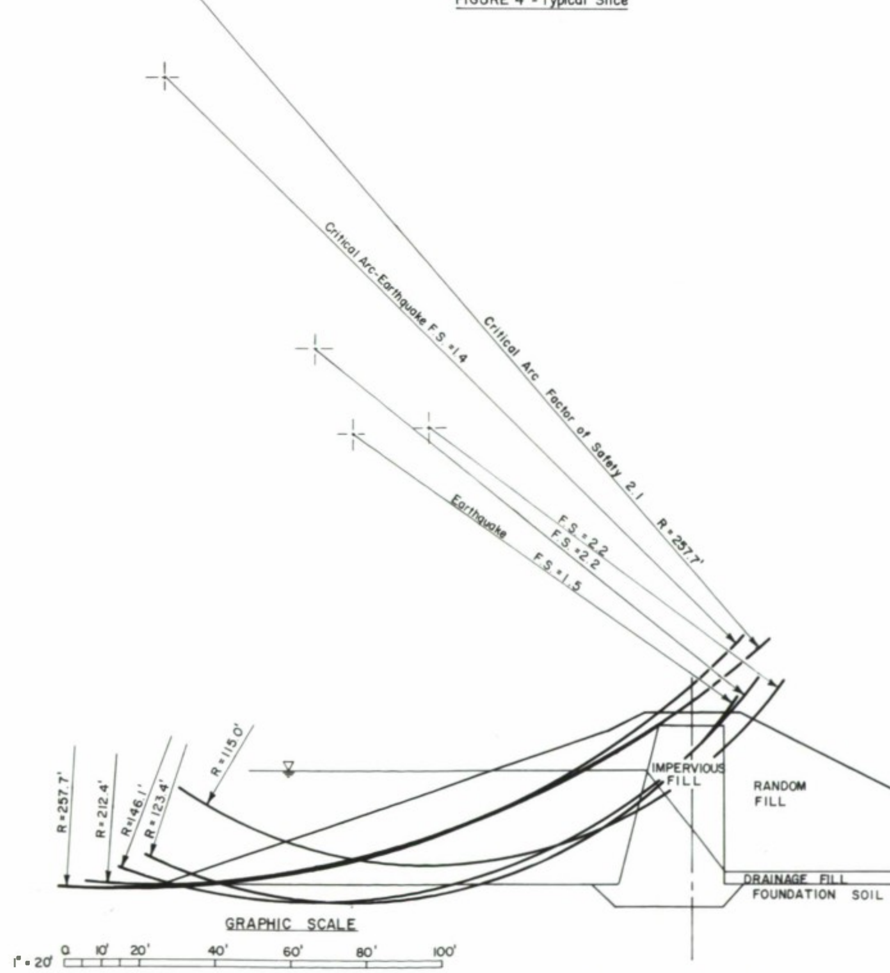


FIGURE 1 - Embankment Section

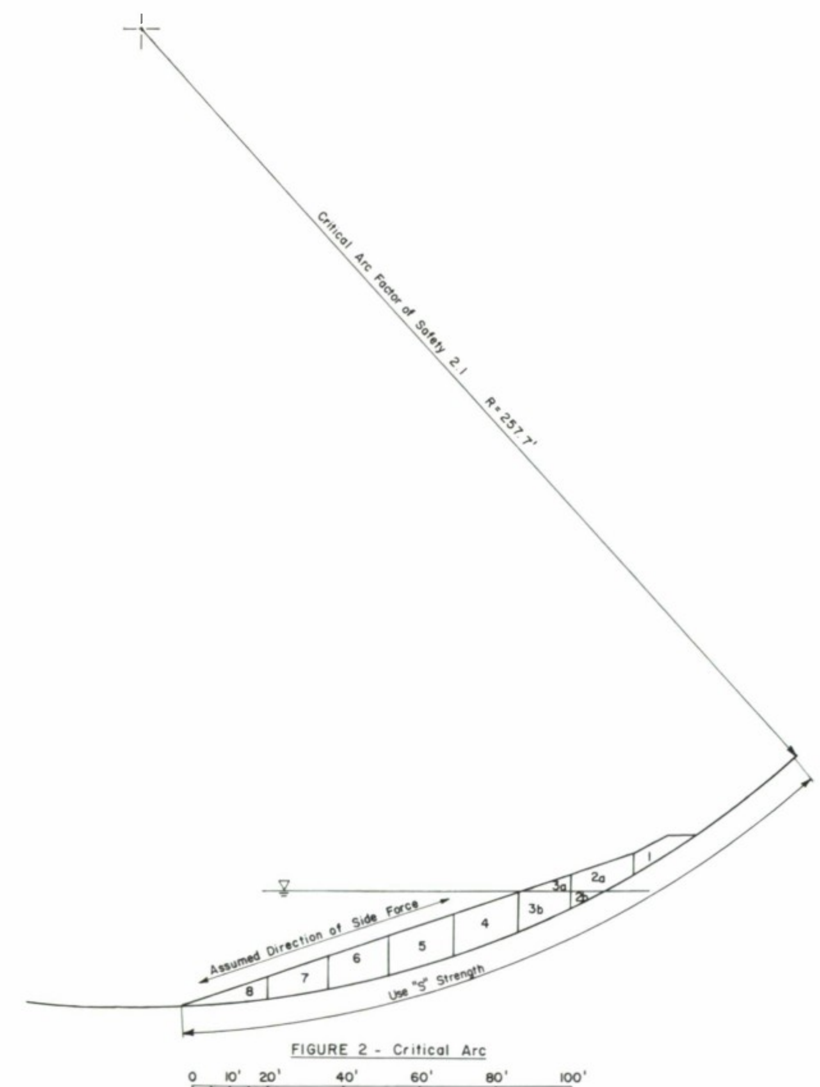


FIGURE 2 - Critical Arc

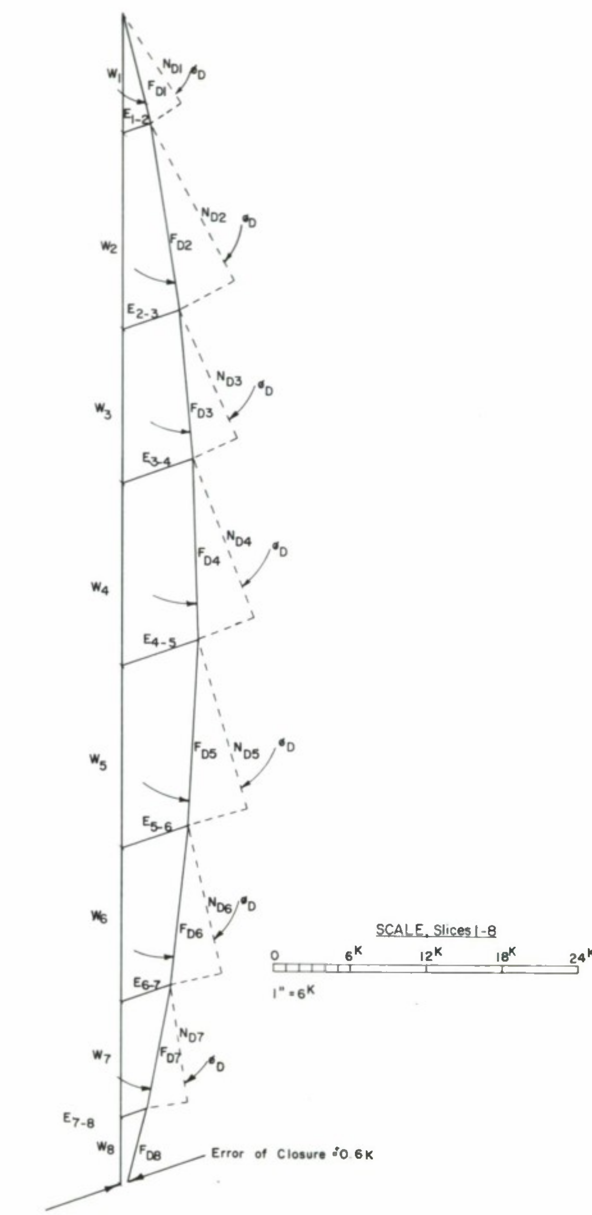


FIGURE 5 - Composite Force Polygon For Trial F.S. 2.1

NOTES

1. Partial Pool analysis for finite slice method performed by Harris Computer System using program no. 741X6L2040 developed by St. Paul District, Corps of Engineers.
2. The computer solution for the critical arc shown was a factor of safety of 2.1. The manual check of this solution confirmed the results.
3. The seismic condition assumes a horizontal force of 0.10 times the slice weight.
4. The shear strengh used for each slice in the force polygon was selected by trial. If the normal force N_D determined using the S strength exceeded 1.6 KSF times the base length of the slice, the $\frac{R+S}{2}$ strength would have been used. This was not the case with any of the slices.

REVISION	DATE	DESCRIPTION	BY	BY

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DESIGNED: K. Swanson
DRAWN: K. Wahl
CHECKED: D. Anderson

REDBANK AND FANCHER CREEKS, CALIFORNIA
FANCHER CREEK
FANCHER CREEK DAM
STABILITY ANALYSIS
PARTIAL POOL

SUBMITTED: CHIEF, SOILS DESIGN SECTION
DATE APPROVED:
SCALE:
SPEC. No.
SHEET F 24 / 77
FILE No. SJ-11-20-11

Slice No.	Segment No.	Area of Segment (Sq Ft)	γ_m (PCF)	γ_s (PCF)	γ_b (PCF)	Segment Weight Before Drawdown (Kips)	Segment Weight After Drawdown (Kips)	Slice Weight Before Drawdown (Kips)	Slice Weight After Drawdown (Kips)	ϕ_D* (Degree)	Arc Length (Feet)
1	-	16.7	131.0	–	–	2.2	-	2.2	2.2	18.28	8.7
2	2a	43.8	131.0	–	–	5.7	5.7	11.0	15.3	18.28	17.1
2	2b	70.0	–	137.8	75.4	5.3	9.6				
3	-	183.0	–	137.8	75.4	13.8	25.2	13.8	25.2	18.28	18.3
4	–	202.5	-	137.8	75.4	15.3	27.9	15.3	27.9	18.28	15.6
5	-	216.2	–	137.8	75.4	16.3	29.8	16.3	29.8	18.28	15.1
6	–	208.5	-	137.8	75.4	15.7	28.7	15.7	28.7	18.28	14.7
7	-	195.0	–	137.8	75.4	14.7	26.9	14.7	26.9	18.28	14.5
8	-	164.7	–	137.8	75.4	12.4	22.7	12.4	22.7	18.28	14.5
9	-	113.1	-	137.8	75.4	8.5	15.6	8.5	15.6	18.28	14.2
10	-	65.2	–	137.8	75.4	4.9	9.0	4.9	9.0	18.28	18.4

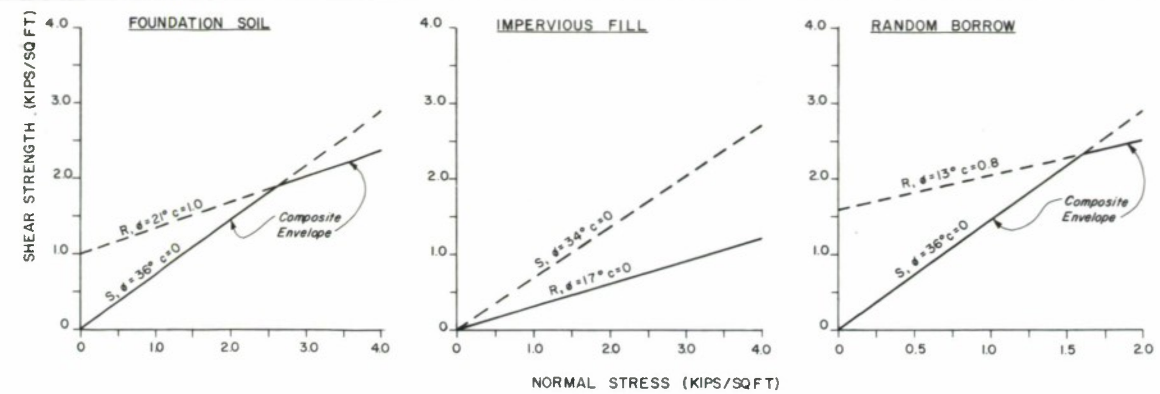
* $\phi_D = \text{Arc tan } \frac{\tan \phi}{F.S.} = \text{Arc tan } \frac{\tan 36°}{2.2} = 18.28°$

Slice No.	N_D (Kips)	Tan θ	N_D Tan ϕ	W (Kips)	θ	sin θ	W sin θ
1	2.1	-	-	2.2	38.5	0.62	1.4
2	9.9	-	-	15.3	34.0	0.56	8.6
3	12.5	-	-	25.2	29.5	0.49	12.4
4	13.9	-	-	27.9	25.0	0.42	11.8
5	15.5	-	-	29.8	20.8	0.36	10.6
6	15.2	-	-	28.7	15.9	0.27	7.9
7	14.4	-	-	26.9	12.7	0.22	5.9
8	12.9	-	-	22.7	8.7	0.15	3.4
9	9.5	-	-	15.6	3.8	0.07	1.0
10	5.0	-	-	9.0	0.5	0.01	0.1
Σ1-10	110.9	0.73	81.0	203.3	-	-	63.1

$$F.S. = \frac{\Sigma N_D \tan \theta}{W \sin \theta} = \frac{81.0}{63.1} = 1.3 \text{ (After Drawdown)}$$

N_D = Normal Effective Force Before Drawdown

W = Weight of Slice After Drawdown



Material	ADOPTED DESIGN DATA					
	"S" Strength		"R" Strength		Unit Weight (PCF)	
	ϕ Degree	Cohesion Kips/SqFt	ϕ Degree	Cohesion Kips/SqFt	γ_m	γ_{sat}
Random Fill	36	0	13	0.8	131.0	137.8
Impervious Fill	34	0	17	0	131.6	137.6
Foundation Soil	36	0	21	1.0	129.3	132.2

FIGURE 3 - Composite Strength Envelopes

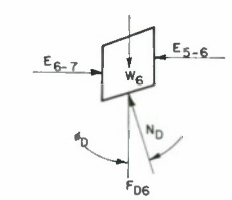


FIGURE 4 - Typical Slice

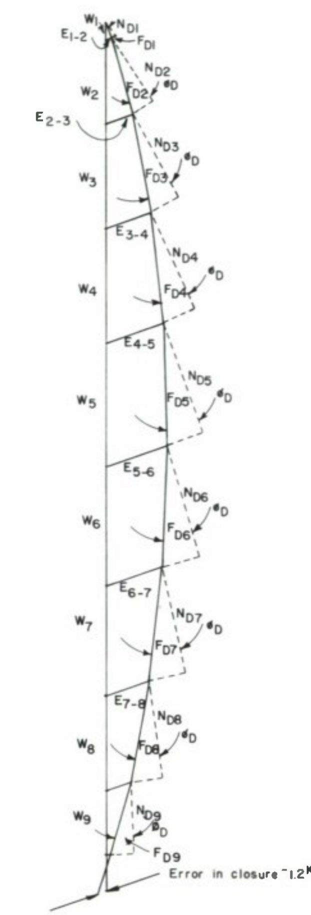


FIGURE 5 - Composite Force Polygon For F.S. 2.2 (Before Drawdown)

GRAPHIC SCALE

1" = 10 Kips 0 10K 20K 30K 40K 50K

LEGEND

- N_D - Normal effective force before drawdown
- W - Weight of slice after drawdown
- γ_m - Moist unit weight
- γ_s - Saturated unit weight
- γ_b - Bouyant unit weight
- h - Horizontal run per 1 foot vertical rise (upstream slope)

NOTES

1. Sudden Drawdown analysis for finite slice method performed by Harris Computer System using program no 741X6L2D40 developed by St. Paul District, Corps of Engineers.
2. The computer solution for the arc shown had a before drawdown factor of safety of 2.2 and an after drawdown factor of safety of 1.3. The manual check of this solution confirmed the result.
3. The solution shown was chosen due to its significant nature, and is not the critical solution. The critical solution was found using an infinite slope analysis. The critical factor of safety is as follows:
$$F.S._{crit} = \frac{\gamma'}{\gamma_s} b \tan \phi = \frac{75.4}{137.8} (3) \tan 36 = 1.2$$
4. The shear strength used for each slice in the force polygon was selected by trial. If the normal force N_D determined using the S strength exceeded 1.6 KSF times the base length of the slice, the R strength would have been used for that slice. This was not the case for any of the slices.

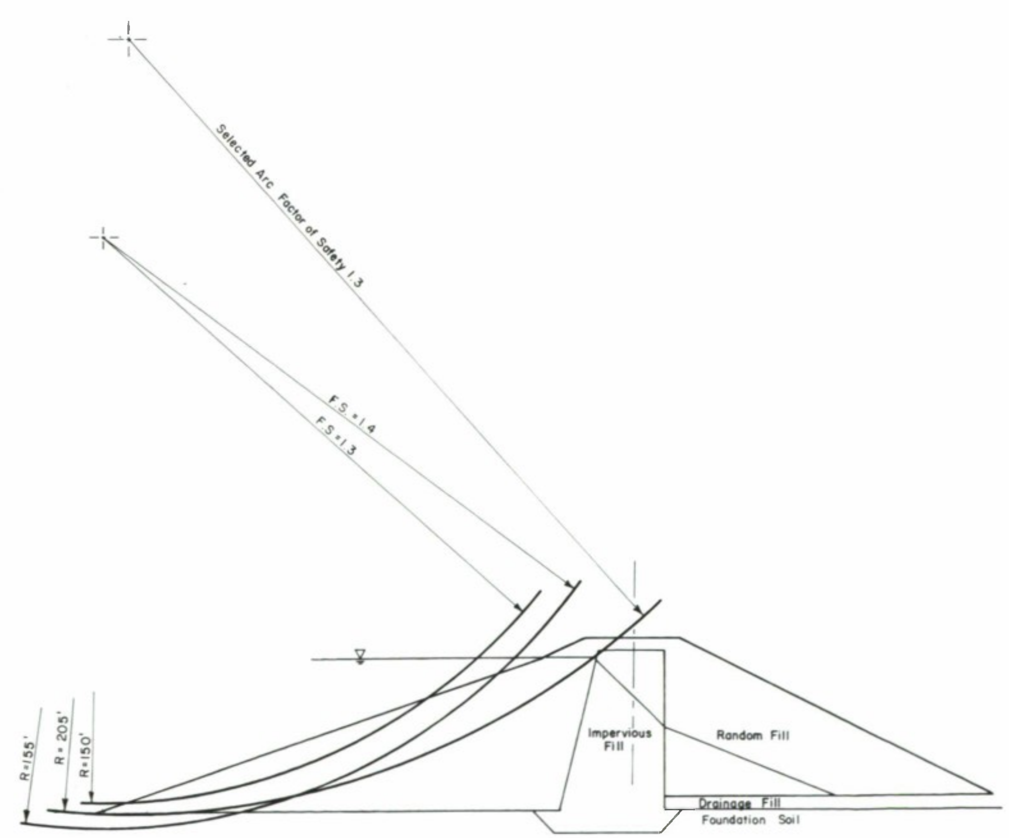


FIGURE 1 - Embankment Section

GRAPHIC SCALE

1" = 20' 0 10' 20' 40' 60' 80' 100'

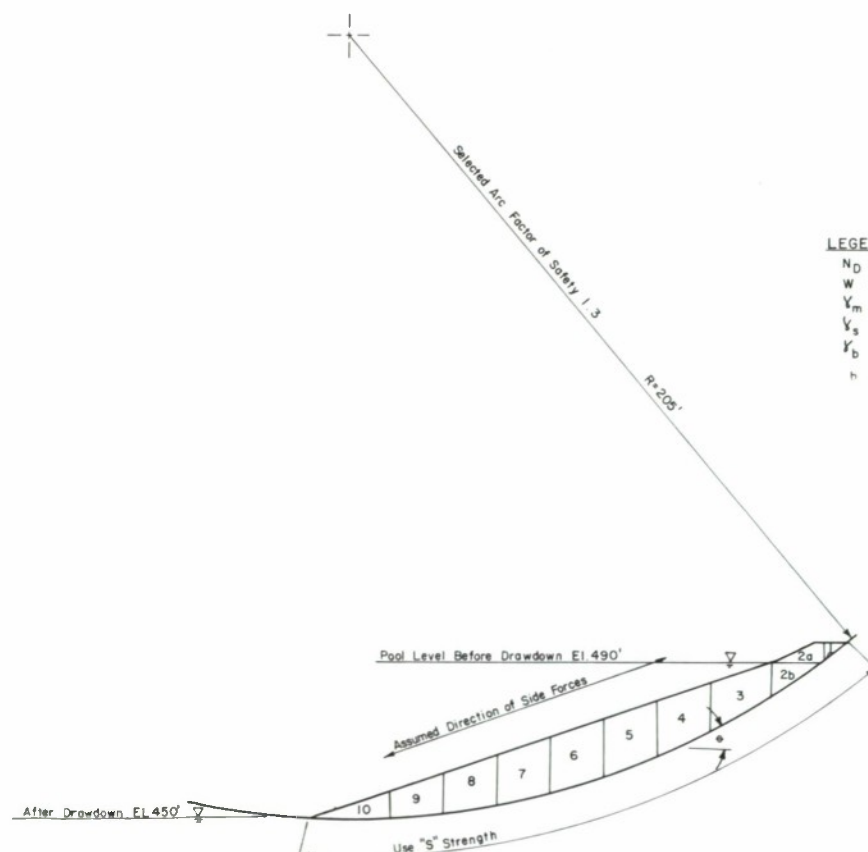


FIGURE 2 - Critical Arc

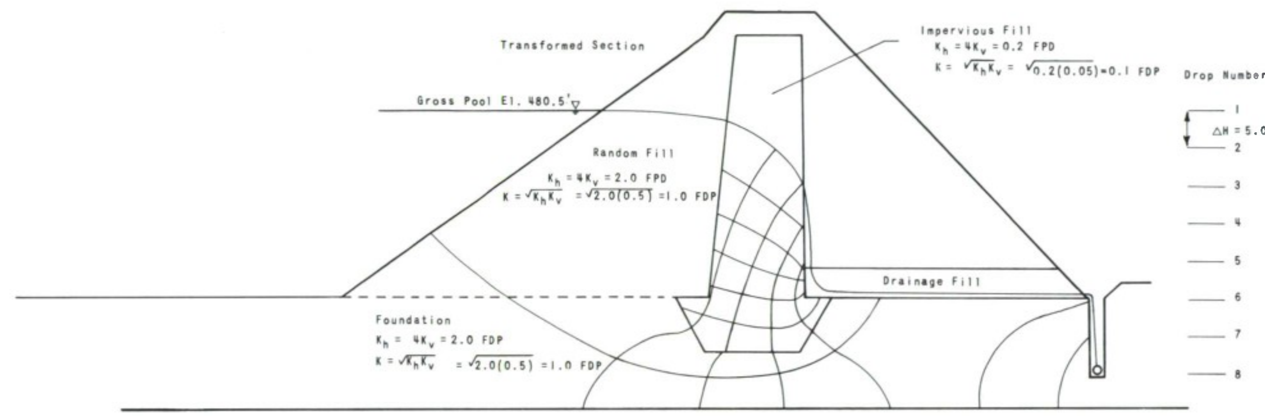
REVISION	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DESIGNED: K. Swanson
DRAWN: K. Wahl
CHECKED: D. Anderson
SUBMITTED:
CHIEF, SOILS DESIGN SECTION

REDBANK AND FANCHER CREEKS, CALIFORNIA
FANCHER CREEK
FANCHER CREEK DAM
STABILITY ANALYSIS
SUDDEN DRAWDOWN

DATE APPROVED: 4/ /86
SCALE:
SHEET F 25 / 78
FILE No. SJ-11-20-11
SPEC. No.



FLOW NET

1" = 20'H
1" = 10'V

SEEPAGE ESTIMATE:

1. If steady state seepage conditions develops, the total seepage flow can be estimated as follows:

$$Q = KH \frac{n_f}{n_d} L = 1.0\ (35)\ \left(\frac{1.5}{7}\right)\ (12,450) = 93,375 \text{ CFD}$$
$$= 1.1 \text{ CFS}$$

2. Of the total estimated seepage, 90% or 0.99 CFS will be collected in the horizontal and toe drains, while 10% or 0.11 CFS will be confined to the foundation.

NOTES:

1. The lower seepage boundry was assumed equal to the average depth of foundation soil located at or below Gross Pool elevation 480.5'. Relatively impervious decomposed granite underlies the soil.
2. The effective length was taken as the length of dam foundation at or below elevation 470.0'.

GRAPHIC SCALES

Horizontal Scale 1" = 20' 0 10' 20' 40' 60' 80' 100'

Vertical Scale 1" = 10' 0 5' 10' 20' 30' 40' 50'

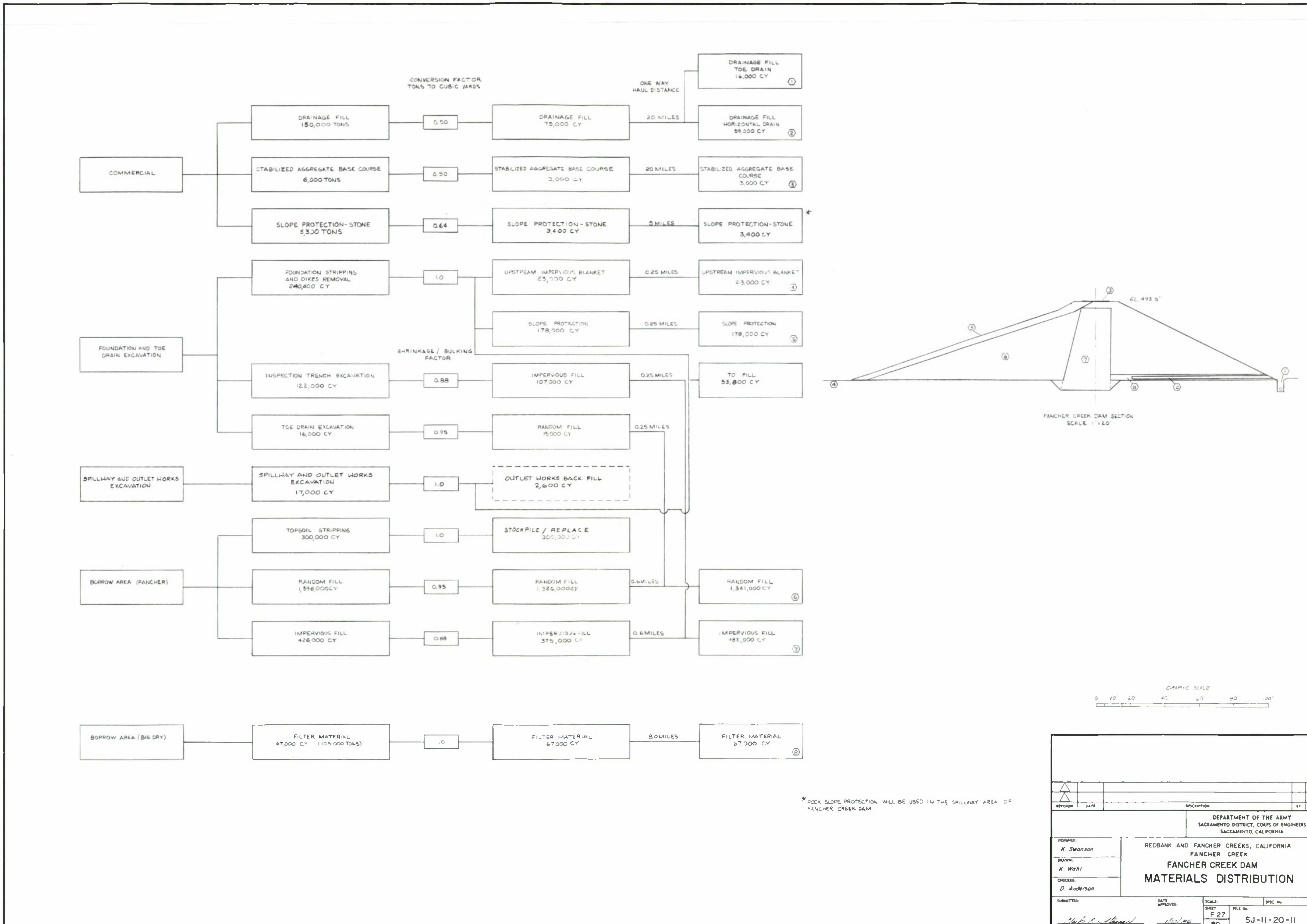
REVISION	DATE	DESCRIPTION	BY

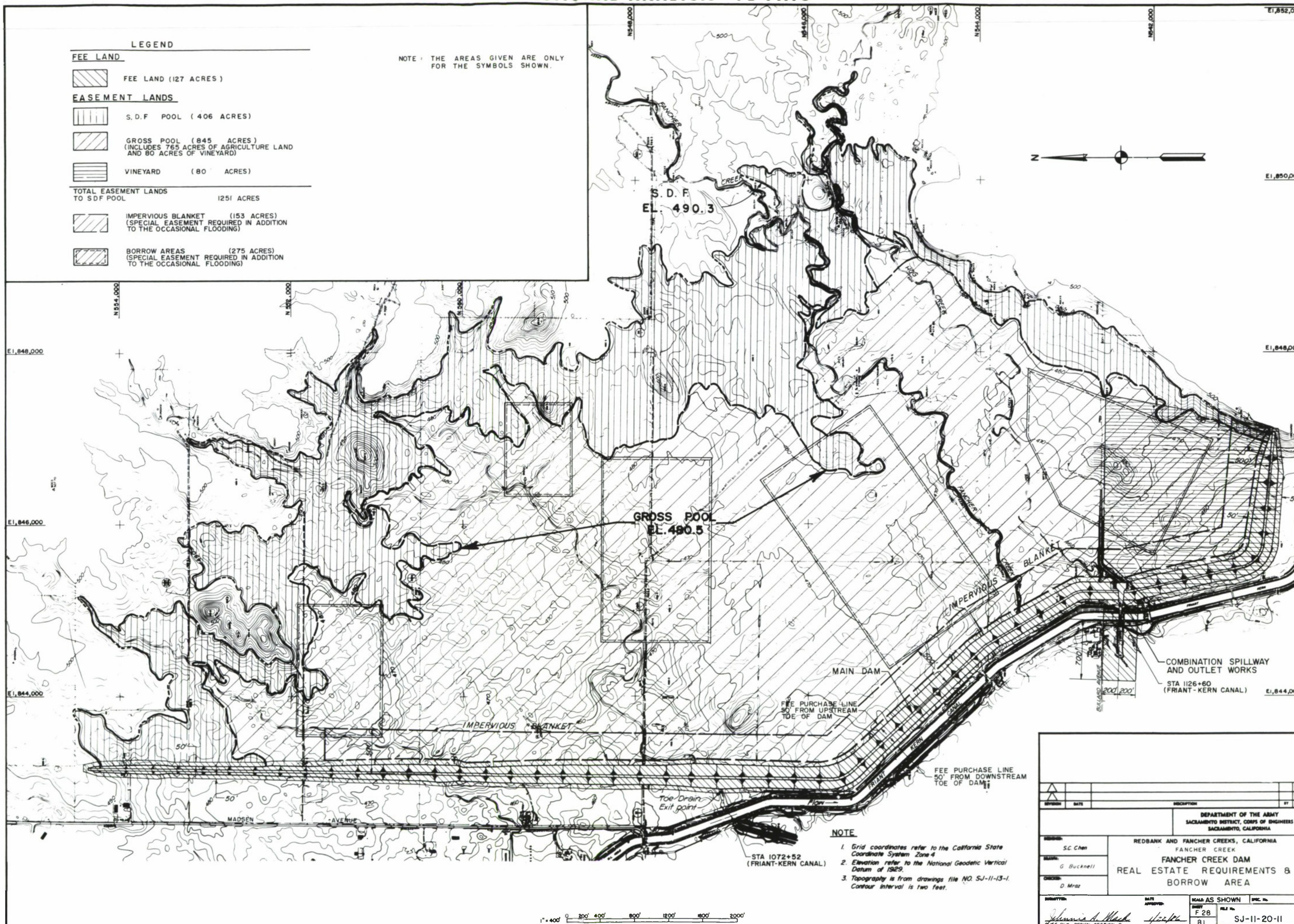
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

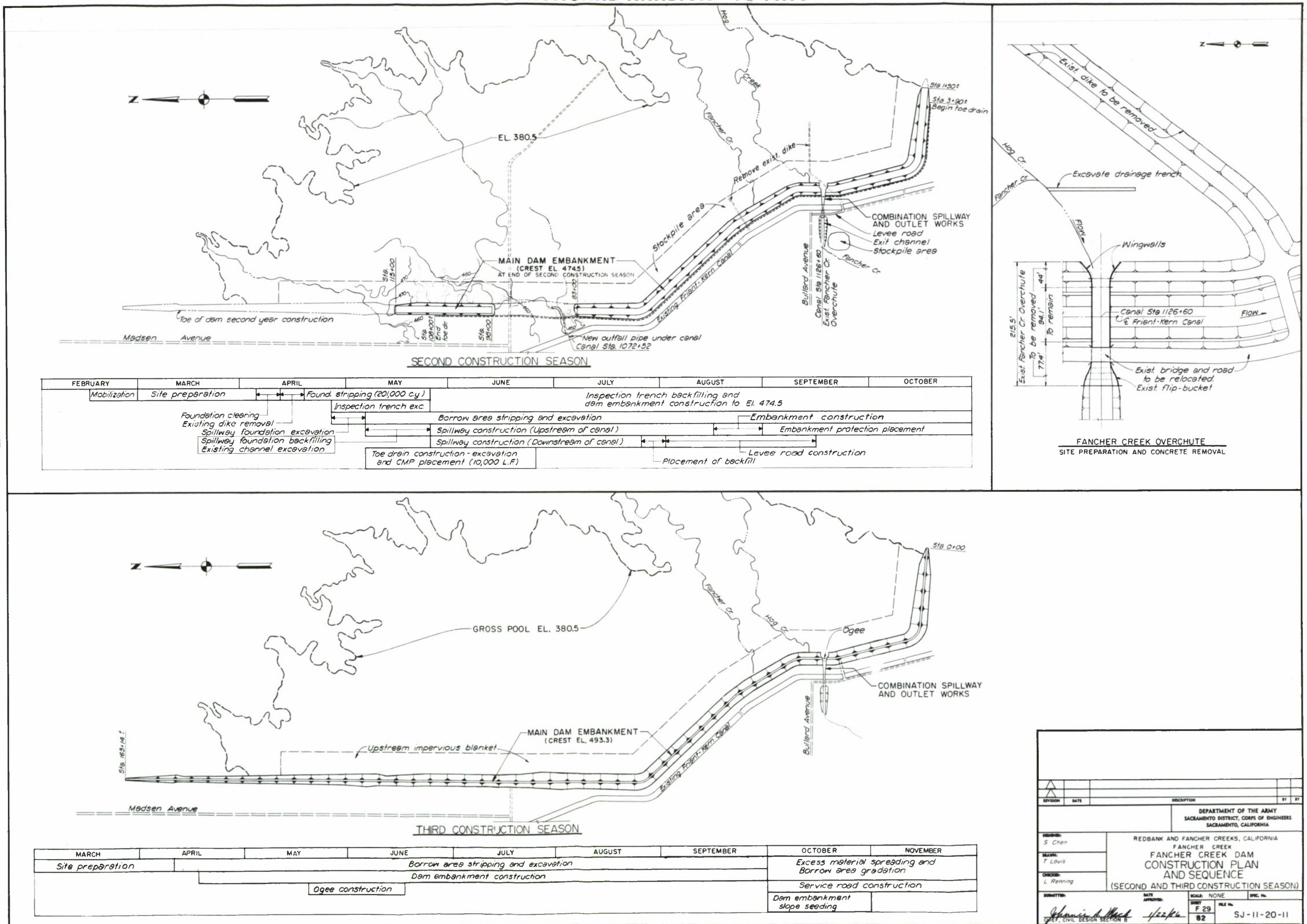
DESIGNED: D. Ricketts
DRAWN: K Wohl
CHECKED: D. Anderson

REDBANK AND FANCHER CREEKS, CALIFORNIA
FANCHER CREEK
FANCHER CREEK DAM
SEEPAGE ANALYSIS

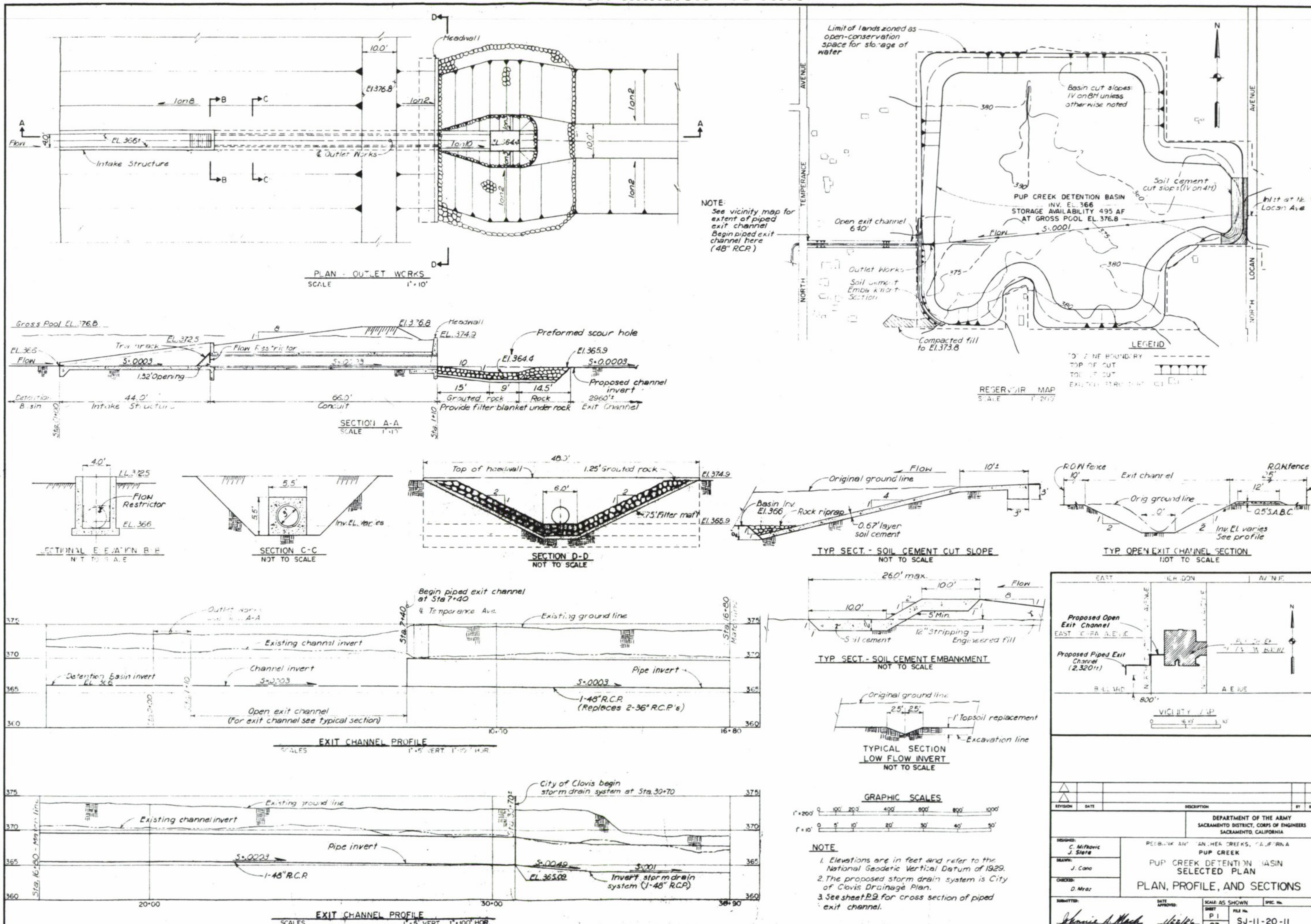
SUBMITTED: CHIEF, SOILS DESIGN SECTION
DATE APPROVED:
SCALE:
SHEET F 26 / 79
FILE No. SJ-11-20-11
SPEC. No.

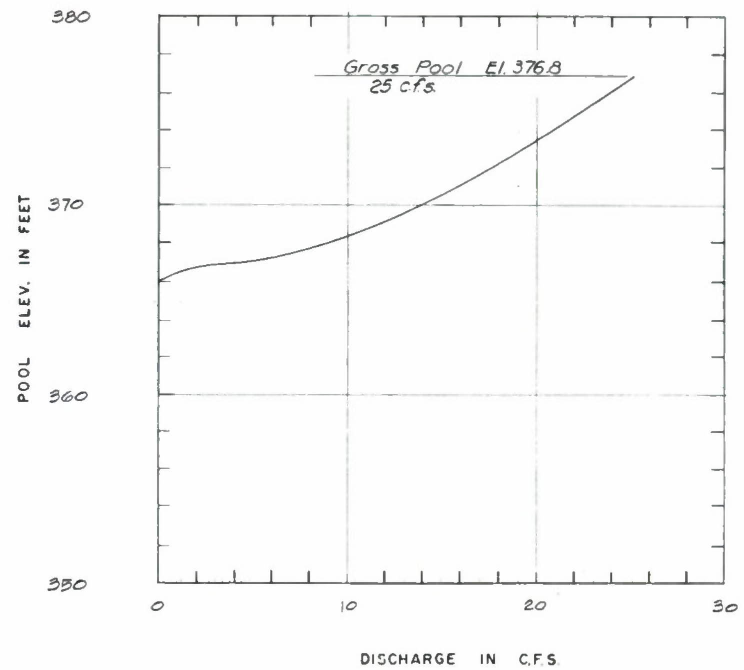

CONVERSION FACTOR TONS TO CUBIC YARDS
ONE WAY HAUL DISTANCE
SHRINKAGE / BULKING FACTOR
COMMERCIAL
FOUNDATION AND TOE DRAIN EXCAVATION
SPILLWAY AND OUTLET WORKS EXCAVATION
BORROW AREA (FANCHER)
BORROW AREA (BIG DRY)
DRAINAGE FILL 150,000 TONS
STABILIZED AGGREGATE BASE COURSE 6,000 TONS
SLOPE PROTECTION - STONE 5,330 TONS
FOUNDATION STRIPPING AND DIKES REMOVAL 240,400 CY
INSPECTION TRENCH EXCAVATION 122,000 CY
TOE DRAIN EXCAVATION 16,000 CY
SPILLWAY AND OUTLET WORKS EXCAVATION 17,000 CY
TOPSOIL STRIPPING 300,000 CY
RANDOM FILL 1,396,000 CY
IMPERVIOUS FILL 426,000 CY
FILTER MATERIAL 67,000 CY (105,000 TONS)
0.50
0.50
0.64
1.0
0.88
0.95
1.0
1.0
0.95
0.88
1.0
DRAINAGE FILL 75,000 CY
STABILIZED AGGREGATE BASE COURSE 3,000 CY
SLOPE PROTECTION - STONE 3,400 CY
UPSTREAM IMPERVIOUS BLANKET 23,000 CY
SLOPE PROTECTION 178,000 CY
IMPERVIOUS FILL 107,000 CY
RANDOM FILL 15,000 CY
OUTLET WORKS BACK FILL 2,600 CY
STOCKPILE / REPLACE 300,000 CY
RANDOM FILL 1,326,000 CY
IMPERVIOUS FILL 375,000 CY
FILTER MATERIAL 67,000 CY
20 MILES
20 MILES
5 MILES
0.25 MILES
0.25 MILES
0.25 MILES
0.25 MILES
0.6 MILES
0.6 MILES
8.0 MILES
DRAINAGE FILL TOE DRAIN 16,000 CY ①
DRAINAGE FILL HORIZONTAL DRAIN 59,000 CY ②
STABILIZED AGGREGATE BASE COURSE 3,000 CY ③
* SLOPE PROTECTION - STONE 3,400 CY
UPSTREAM IMPERVIOUS BLANKET 23,000 CY ④
SLOPE PROTECTION 178,000 CY ⑤
TO FILL 53,800 CY
RANDOM FILL 1,341,000 CY ⑥
IMPERVIOUS FILL 482,000 CY ⑦
FILTER MATERIAL 67,000 CY ⑧
EL. 493.5'
FANCHER CREEK DAM SECTION
SCALE 1" = 20'
GRAPHIC SCALE
0 10' 20 40 60 80 100'
* ROCK SLOPE PROTECTION WILL BE USED IN THE SPILLWAY AREA OF FANCHER CREEK DAM
REVISION DATE DESCRIPTION BY
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
DESIGNED: K. Swanson
DRAWN: K. Wahl
CHECKED: D. Anderson
SUBMITTED:
CHIEF, SOILS DESIGN SECTION
DATE APPROVED:
REDBANK AND FANCHER CREEKS, CALIFORNIA
FANCHER CREEK
FANCHER CREEK DAM
MATERIALS DISTRIBUTION
SCALE:
SHEET F 27
80
FILE No. SJ-11-20-11
SPEC No.


LEGEND
FEE LAND
FEE LAND (127 ACRES)
EASEMENT LANDS
S.D.F POOL (406 ACRES)
GROSS POOL (845 ACRES)
(INCLUDES 765 ACRES OF AGRICULTURE LAND AND 80 ACRES OF VINEYARD)
VINEYARD (80 ACRES)
TOTAL EASEMENT LANDS TO SDF POOL 1251 ACRES
IMPERVIOUS BLANKET (153 ACRES)
(SPECIAL EASEMENT REQUIRED IN ADDITION TO THE OCCASIONAL FLOODING)
BORROW AREAS (275 ACRES)
(SPECIAL EASEMENT REQUIRED IN ADDITION TO THE OCCASIONAL FLOODING)
NOTE: THE AREAS GIVEN ARE ONLY FOR THE SYMBOLS SHOWN.
S.D.F. EL. 490.3
GROSS POOL EL. 480.5
IMPERVIOUS BLANKET
MAIN DAM
FEE PURCHASE LINE 50' FROM UPSTREAM TOE OF DAM
FEE PURCHASE LINE 50' FROM DOWNSTREAM TOE OF DAM
COMBINATION SPILLWAY AND OUTLET WORKS
STA 1126+60 (FRIANT-KERN CANAL)
STA 1072+52 (FRIANT-KERN CANAL)
Toe Drain Exit point
MADSEN AVENUE
FANCHER CREEK
HOG CREEK
E1,852,000
E1,850,000
E1,848,000
E1,846,000
E1,844,000
N554,000
N552,000
N550,000
N548,000
N546,000
N544,000
N542,000
NOTE
1. Grid coordinates refer to the California State Coordinate System Zone 4
2. Elevation refer to the National Geodetic Vertical Datum of 1929.
3. Topography is from drawings file NO. SJ-11-13-1. Contour interval is two feet.
1" = 400' 0 200' 400' 800' 1200' 1600' 2000'
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
REDBANK AND FANCHER CREEKS, CALIFORNIA
FANCHER CREEK
FANCHER CREEK DAM
REAL ESTATE REQUIREMENTS & BORROW AREA
S.C. Chen
G. Bucknell
D. Mraz
CHIEF, CIVIL DESIGN, SECTION B
SCALE AS SHOWN
F 28
81
SJ-11-20-11

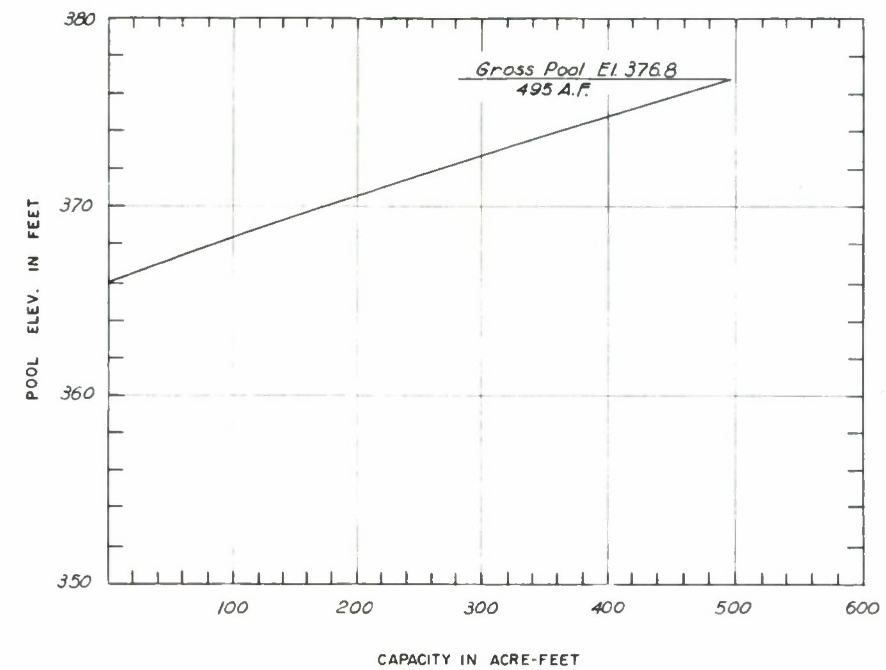


EL. 380.5
Hog Creek
Fancher Cr.
Remove exist. dike
Stockpile area
Sta 1+50±
Sta 3+90± Begin toe drain
COMBINATION SPILLWAY AND OUTLET WORKS
Levee road
Exit channel
Stockpile area
Fancher Cr.
Bullard Avenue
Canal Sta 1126+60
Exist. Fancher Cr. Overchute
MAIN DAM EMBANKMENT
(CREST EL. 474.5)
AT END OF SECOND CONSTRUCTION SEASON
Existing Friant-Kern Canal
Sta. 115+00
Sta. 108+00± End toe dr.
Sta. 98+00
83+00
Toe of dam second year construction
Madsen Avenue
New outfall pipe under canal
Canal Sta. 1072+52
SECOND CONSTRUCTION SEASON
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
Mobilization
Site preparation
Found. stripping (201,000 cy)
Inspection trench backfilling and dam embankment construction to El. 474.5
Inspection trench exc.
Foundation clearing
Existing dike removal
Spillway foundation excavation
Spillway foundation backfilling
Existing channel excavation
Borrow area stripping and excavation
Embankment construction
Spillway construction (Upstream of canal)
Embankment protection placement
Spillway construction (Downstream of canal)
Toe drain construction - excavation and CMP placement (10,000 L.F.)
Levee road construction
Placement of backfill
Exist. dike to be removed
Excavate drainage trench
Hog Cr.
Fancher Cr.
Flow
Wingwalls
215.5'
Exist. Fancher Cr. Overchute
To be removed
94.1'
77.4'
44'
To remain
Canal Sta 1126+60
℄ Friant-Kern Canal
Flow
Exist. bridge and road to be relocated.
Exist. flip-bucket
FANCHER CREEK OVERCHUTE
SITE PREPARATION AND CONCRETE REMOVAL
GROSS POOL EL. 380.5
Sta. 0+00
Fancher Cr.
Hog Cr.
Ogee
COMBINATION SPILLWAY AND OUTLET WORKS
Bullard Avenue
MAIN DAM EMBANKMENT
(CREST EL. 493.3)
Upstream impervious blanket
Existing Friant-Kern Canal
Sta. 163+14±
Madsen Avenue
THIRD CONSTRUCTION SEASON
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
Site preparation
Borrow area stripping and excavation
Excess material spreading and Borrow area gradation
Dam embankment construction
Service road construction
Ogee construction
Dam embankment slope seeding
REVISION
DATE
DESCRIPTION
BY
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
DESIGNED: S. Chen
DRAWN: T. Louis
CHECKED: L. Renning
SUBMITTED:
REDBANK AND FANCHER CREEKS, CALIFORNIA
FANCHER CREEK
FANCHER CREEK DAM
CONSTRUCTION PLAN
AND SEQUENCE
(SECOND AND THIRD CONSTRUCTION SEASON)
CHIEF, CIVIL DESIGN SECTION B
DATE APPROVED: 1/22/86
SCALE: NONE
SHEET F 29
82
SJ-11-20-11

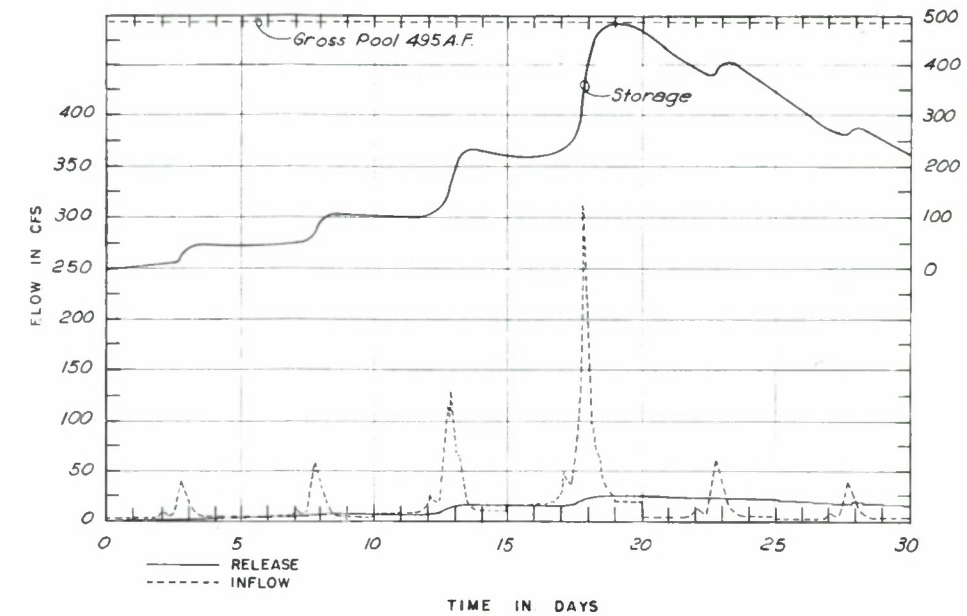

PLAN - OUTLET WORKS
SCALE 1"=10'
Headwall
Intake Structure
℄ Outlet Works
Flow
SECTION A-A
Gross Pool EL.376.8
Preformed scour hole
Flow Restrictor
1.32' Opening
Intake Structure
Conduit
Grouted rock
Rock
Provide filter blanket under rock
Proposed channel invert
Exit Channel
SECTIONAL ELEVATION B-B
NOT TO SCALE
SECTION C-C
NOT TO SCALE
SECTION D-D
NOT TO SCALE
Top of headwall
1.25' Grouted rock
.75' Filter mat
TYP. SECT. - SOIL CEMENT CUT SLOPE
NOT TO SCALE
Original ground line
Rock riprap
0.67' layer soil cement
TYP. OPEN EXIT CHANNEL SECTION
NOT TO SCALE
R.O.W. fence
Exit channel
Orig ground line
Inv. El. varies See profile
TYP. SECT. - SOIL CEMENT EMBANKMENT
NOT TO SCALE
12" Stripping
Engineered fill
Soil cement
TYPICAL SECTION
LOW FLOW INVERT
NOT TO SCALE
1' Topsoil replacement
Excavation line
GRAPHIC SCALES
NOTE
1. Elevations are in feet and refer to the National Geodetic Vertical Datum of 1929.
2. The proposed storm drain system is City of Clovis Drainage Plan.
3. See sheet P9 for cross section of piped exit channel.
Limit of lands zoned as open-conservation space for storage of water
Basin cut slopes: 1V on 8H unless otherwise noted
Soil cement cut slope (1V on 4H)
Inlet at North Locan Ave
PUP CREEK DETENTION BASIN
INV. EL. 366
STORAGE AVAILABILITY 495 AF
AT GROSS POOL EL. 376.8
S=0.0001
NOTE:
See vicinity map for extent of piped exit channel
Begin piped exit channel here (48" R.C.P.)
Open exit channel 640'
Outlet Works
Compacted fill to El. 373.8
LEGEND
RESERVOIR MAP
NORTH TEMPERANCE AVENUE
NORTH LOCAN AVENUE
EXIT CHANNEL PROFILE
SCALES 1"=5' VERT. 1"=100' HOR.
Begin piped exit channel at Sta 7+40
Existing ground line
Existing channel invert
Channel invert
Detention Basin invert
Pipe invert
1-48" R.C.P. (Replaces 2-36" R.C.P.'s)
Open exit channel (For exit channel see typical section)
City of Clovis begin storm drain system at Sta. 30+70
Invert storm drain system (1-48" R.C.P.)
Proposed Open Exit Channel
Proposed Piped Exit Channel (2,320±)
VICINITY MAP
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
PUP CREEK
PUP CREEK DETENTION BASIN
SELECTED PLAN
PLAN, PROFILE, AND SECTIONS
DESIGNED: C. Mifkovic, J. Slate
DRAWN: J. Cano
CHECKED: D. Mraz
SCALE: AS SHOWN
SHEET P1 83
SJ-11-20-11



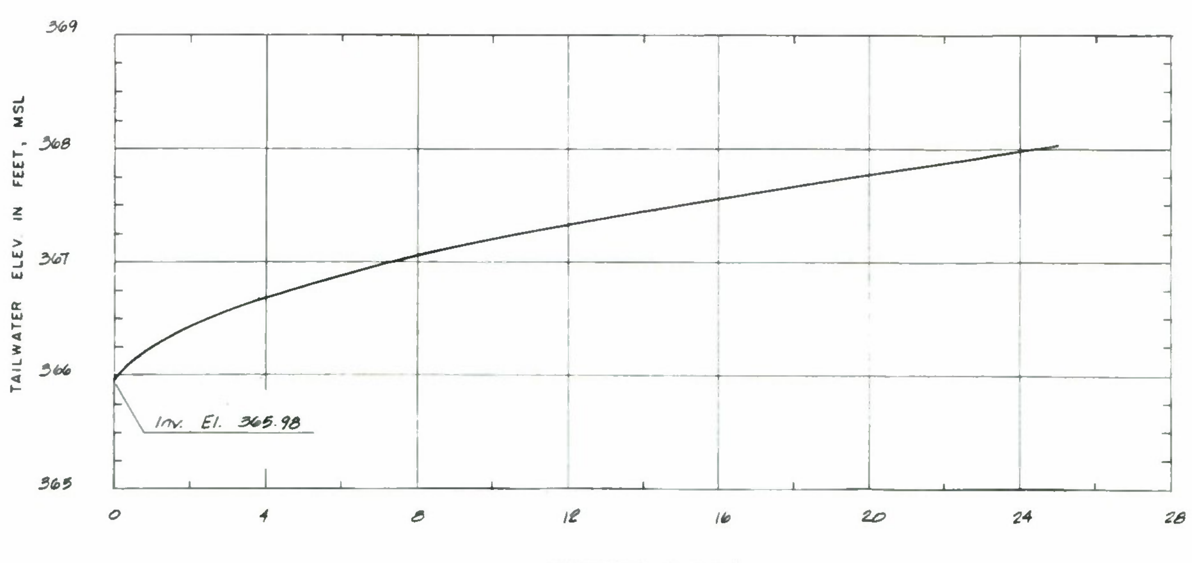
OUTLET WORKS RATING CURVE



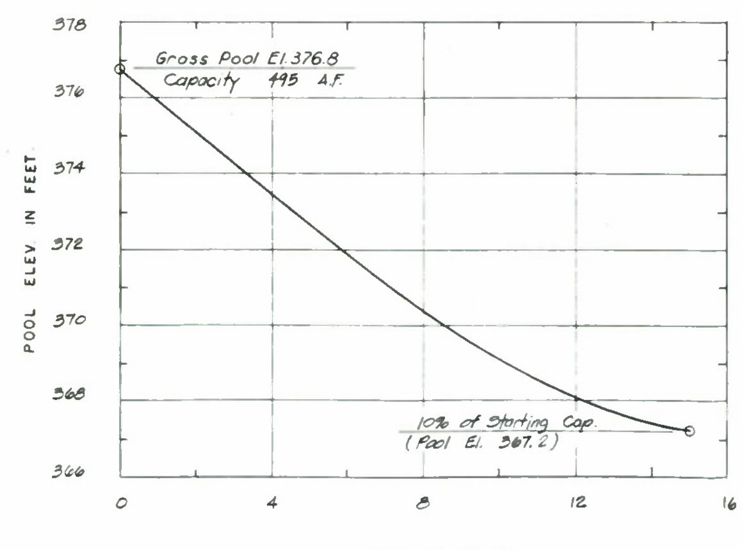
CAPACITY CURVE



BASIN DESIGN FLOOD (200 YEAR) ROUTING CURVE



OUTLET WORKS TAILWATER RATING CURVE

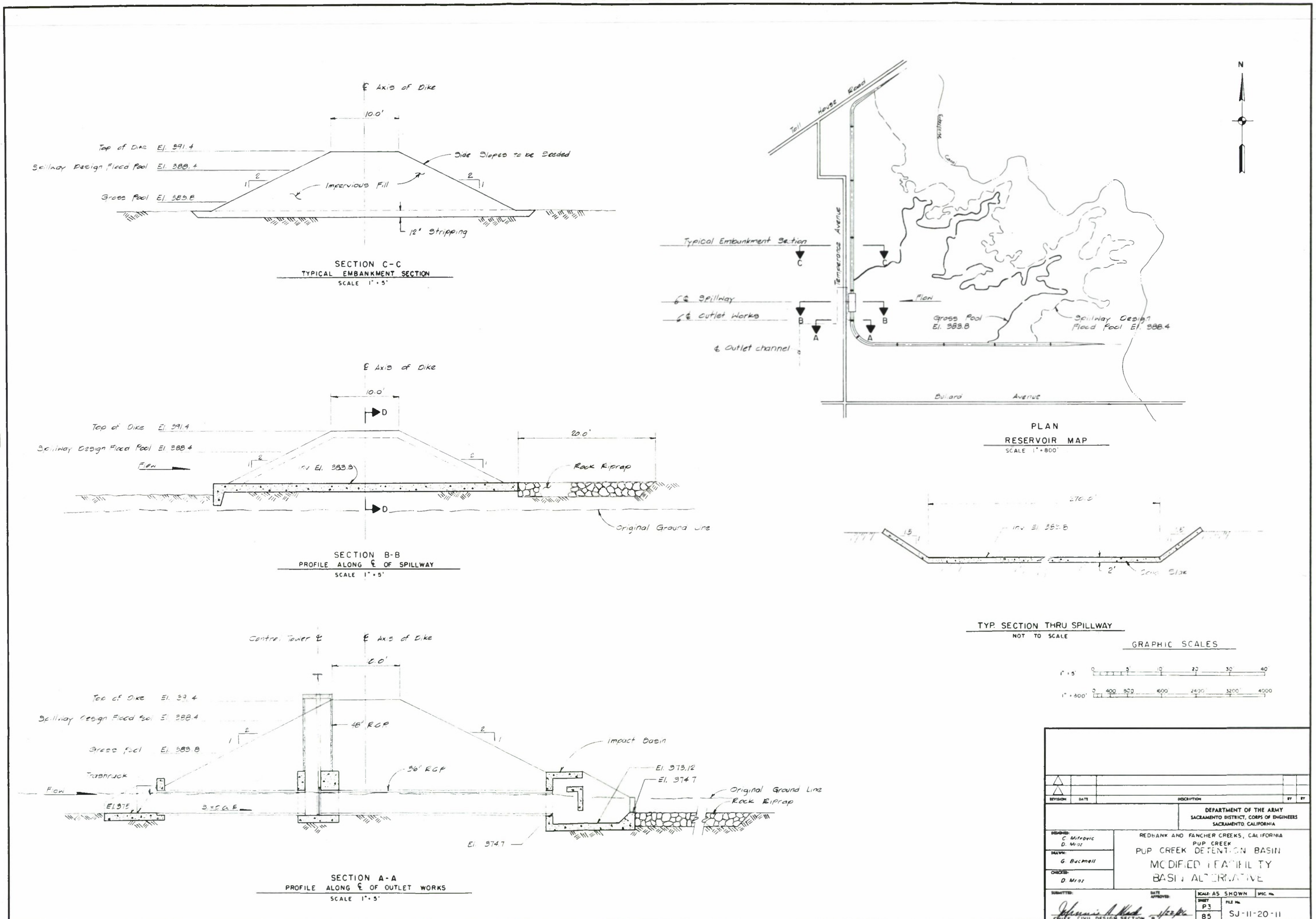


DETENTION BASIN DRAWDOWN CURVE

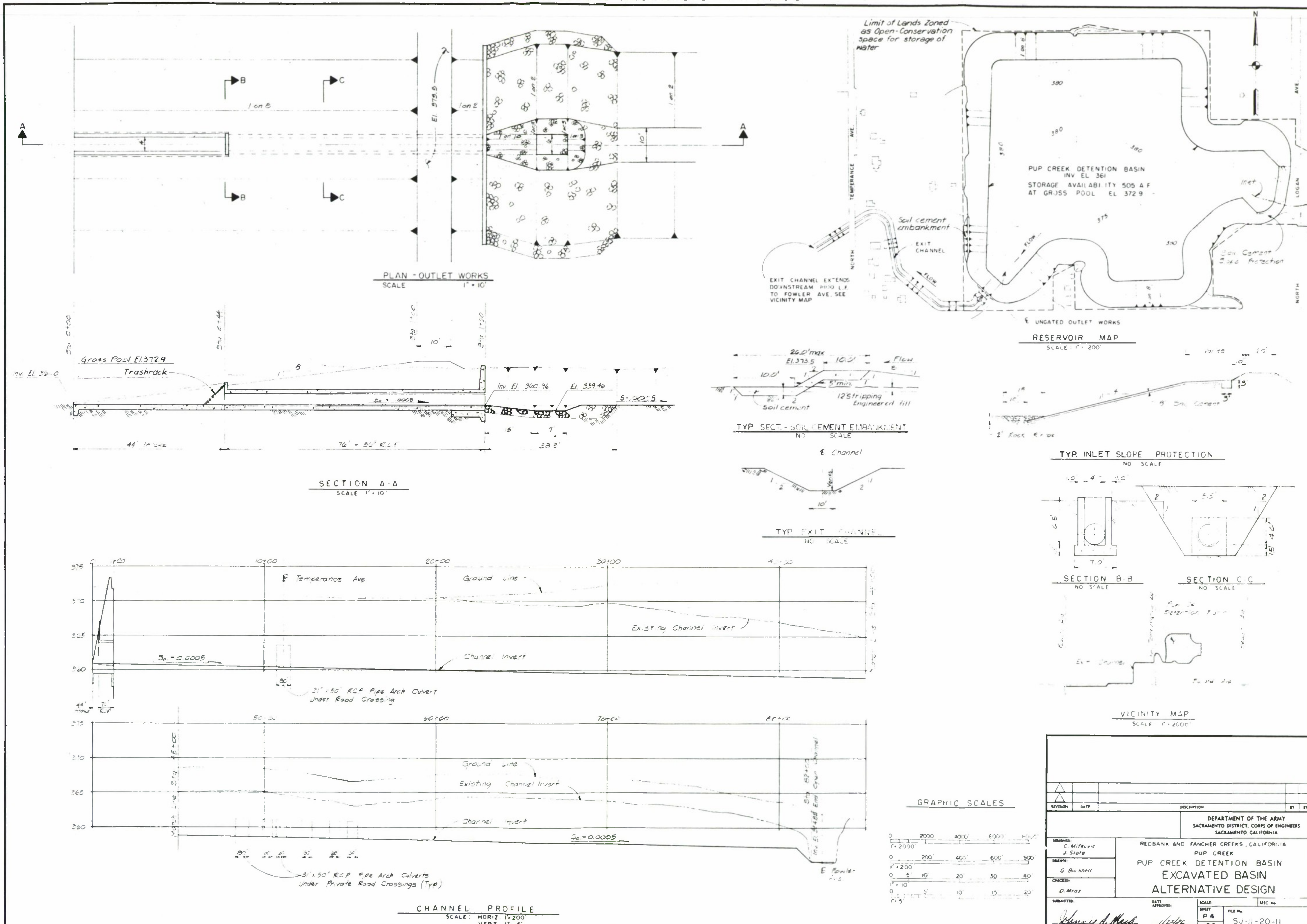
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

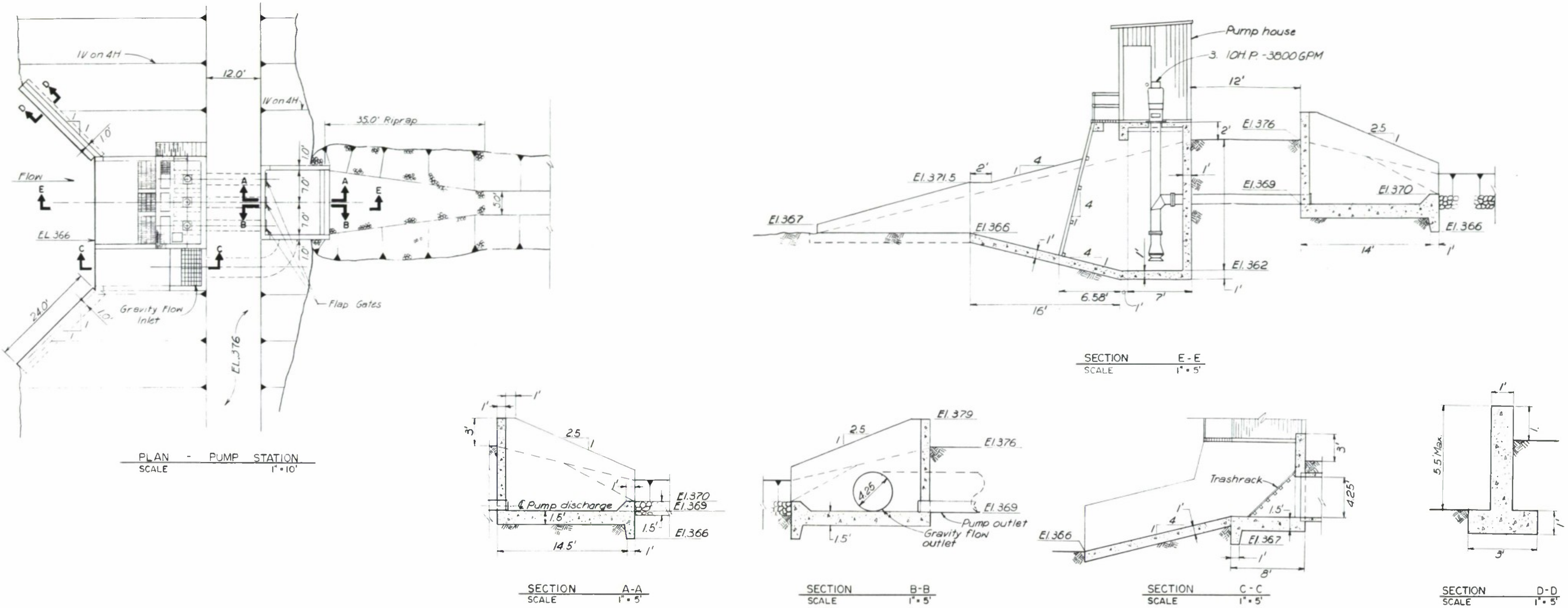
REDBANK AND FANCHER CREEKS, CALIFORNIA
PUP CREEK
PUP CREEK DETENTION BASIN
HYDRAULIC DATA

DESIGNED: B. O'Leary, J. Slote
DRAWN: G. Bucknell
CHECKED: D. Mraz
SUBMITTED: Harold C Huff
CHIEF, HYDRAULIC DESIGN SECTION
DATE APPROVED: 22 JAN 86
SCALE: AS SHOWN
SHEET P2 84
FILE No. SJ-11-20-11

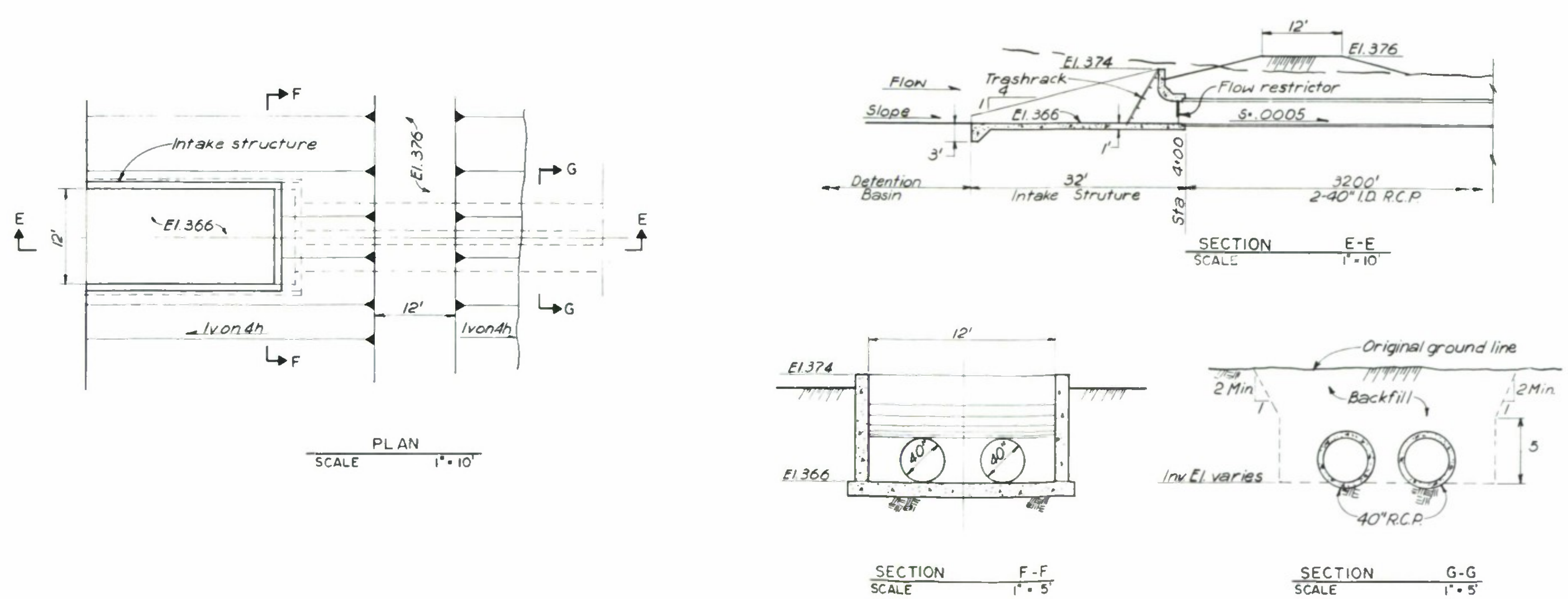


℄ Axis of Dike
10.0'
Top of Dike El. 391.4
Spillway Design Flood Pool El. 388.4
Gross Pool El. 383.8
Side Slopes to be Seeded
Impervious Fill
12" Stripping
SECTION C-C
TYPICAL EMBANKMENT SECTION
SCALE 1"=5'
Rock Riprap
Original Ground Line
Flow
20.0'
SECTION B-B
PROFILE ALONG ℄ OF SPILLWAY
SCALE 1"=5'
Control Tower ℄
48" RCP
36" RCP
Trashrack
Impact Basin
El. 373.12
El. 374.7
SECTION A-A
PROFILE ALONG ℄ OF OUTLET WORKS
SCALE 1"=5'
N
Toll House Road
Temperance Avenue
Bullard Avenue
Typical Embankment Section
℄ Spillway
℄ Outlet Works
℄ Outlet channel
Flow
Gross Pool El. 383.8
Spillway Design Flood Pool El. 388.4
PLAN
RESERVOIR MAP
SCALE 1"=800'
TYP. SECTION THRU SPILLWAY
NOT TO SCALE
GRAPHIC SCALES
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
REDBANK AND FANCHER CREEKS, CALIFORNIA
PUP CREEK
PUP CREEK DETENTION BASIN
MODIFIED FEASIBILITY
BASIN ALTERNATIVE
C. Mitrovic
D. Mraz
G. Bucknell
D. Mraz
CHIEF, CIVIL DESIGN SECTION
SCALE: AS SHOWN
P3
85
SJ-11-20-11


PLAN - OUTLET WORKS
SCALE 1" = 10'
SECTION A-A
SCALE 1" = 10'
Gross Pool El 372.9
Trashrack
Inv El 360.96
El 359.46
RESERVOIR MAP
SCALE 1" = 200'
PUP CREEK DETENTION BASIN
INV EL 361
STORAGE AVAILABILITY 505 A F
AT GROSS POOL EL 372.9
Limit of Lands Zoned as Open-Conservation Space for storage of water
Soil cement embankment
EXIT CHANNEL
EXIT CHANNEL EXTENDS DOWNSTREAM TO FOWLER AVE. SEE VICINITY MAP
UNGATED OUTLET WORKS
TEMPERANCE AVE.
LOGAN AVE.
NORTH
TYP. SECT - SOIL CEMENT EMBANKMENT
NO SCALE
Soil cement
12" Stripping
Engineered fill
TYP. INLET SLOPE PROTECTION
NO SCALE
TYP. EXIT CHANNEL
NO SCALE
SECTION B-B
NO SCALE
SECTION C-C
NO SCALE
VICINITY MAP
SCALE 1" = 2000'
CHANNEL PROFILE
SCALE: HORIZ 1" = 200'
VERT 1" = 5'
Ground Line
Existing Channel Invert
Channel Invert
21" x 30" RCP Pipe Arch Culvert Under Road Crossing
31" x 50" RCP Pipe Arch Culverts Under Private Road Crossings (Typ.)
GRAPHIC SCALES
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
REDBANK AND FANCHER CREEKS, CALIFORNIA
PUP CREEK
PUP CREEK DETENTION BASIN
EXCAVATED BASIN
ALTERNATIVE DESIGN
DESIGNED: C. Mitkovic, J. Slota
DRAWN: G. Bucknell
CHECKED: D. Mraz
SHEET P 4 / 86
FILE No. SJ-11-20-11



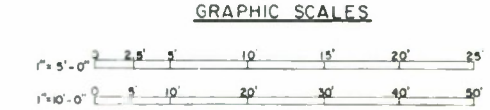
PUMPED FLOW ALTERNATIVE



1. Elevations are in feet and refer to the National Geodetic Vertical Datum of 1929.
2. See sheet P1 for additional alternative outlet works.

PIPED FLOW ALTERNATIVE

GRAPHIC SCALES



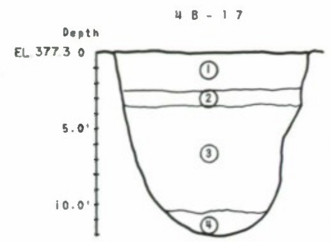
REVISION	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

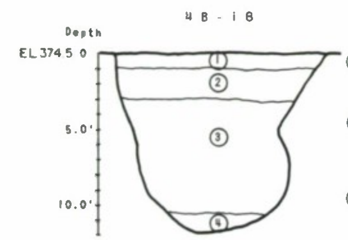
DESIGNED: D. Mraz
DRAWN: J. Cano
CHECKED: T. Louis
SUBMITTED: Johnnie A. Mack, CHIEF, CIVIL DESIGN SECTION B
DATE APPROVED: 1/22/86

REDBANK AND FANCHER CREEKS, CALIFORNIA
PUP CREEK
PUP CREEK DETENTION BASIN
ALTERNATIVE OUTLET WORKS

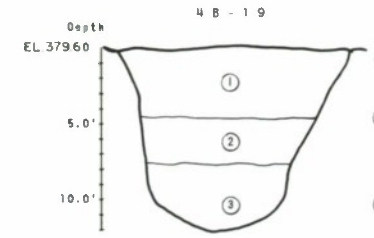
SCALE: AS SHOWN
SHEET: P5 / 87
FILE No.: SJ-11-20-11



1. SILTY SAND (SM), reddish-brown, dry, est. 70% very fine to medium grained sand with scattered coarse subrounded grains, est. 30% non- to low plasticity fines, firm to very firm, moderately cemented (F.C.)
2. SANDY SILT (ML), dark reddish-brown, dry, est. 60-70% low plasticity fines, est. 30-40% very fine to fine grained sand, stiff to very stiff, moderately cemented (F.C.)
3. CLAYEY SAND (SC), reddish-brown, 10% moisture content, 75% graded angular to subangular grained sand, 24% medium plasticity fines (LL = 46, PI = 22), 1% fine gravel, loose to firm
4. *CLAYEY SAND (SC), yellowish-brown, moist, est. 75% graded angular to subrounded grained sand, est. 25% medium plasticity fines, traces of fine gravel, firm to very firm



1. SILTY SAND (SM), tannish-gray, dry, est. 60% very fine to medium grained sand, est. 40% low plasticity fines, dense, non-cemented (F.C.)
2. *CLAYEY SAND (SC), reddish-brown, 10% moisture content, est. 65% graded sand, est. 35% medium plasticity fines, traces of fine gravel, firm, non-cemented
3. SILTY SAND (SM), medium to light brown with iron oxide staining, 8% moisture content, 84% very fine to medium grained sand, 15% non-plastic fines, 1% gravel to 3/8" maximum, very firm to dense, moderately cemented, G_s = 2.69
4. SANDY SILT, dark yellowish-brown, damp, est. 60% low plasticity fines, est. 40% very fine to medium subangular to subrounded sand, very firm to stiff, moderately cemented (F.C.)



1. *SANDY CLAY (CL), reddish-brown, damp, est. 60% medium to high plasticity fines, est. 40% graded sand, stiff, non-cemented
2. CLAYEY SAND (SC), brown to reddish-brown, 10% moisture content, 59% very fine to medium subangular to subrounded grained sand, 41% medium plasticity fines (LL = 38, PI = 21), firm, slightly cemented
3. SILTY SAND (SM), reddish-brown with iron oxide staining, damp, est. 60-70% very fine to fine grained sand, est. 30-40% low plasticity fines, very firm, slightly cemented (F.C.)

Scale: 1" = 5'

UNIFIED SOIL CLASSIFICATION SYSTEM

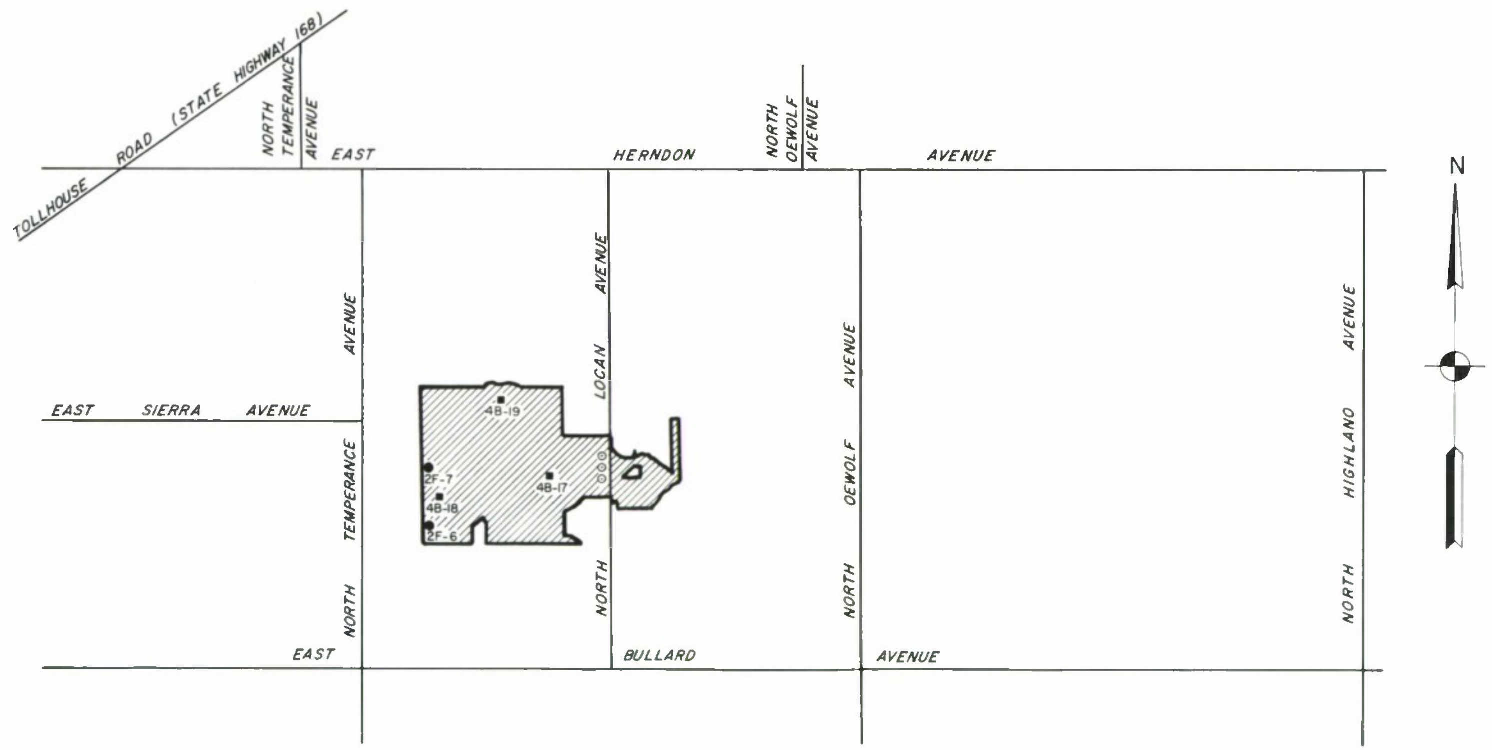
MAJOR DIVISIONS			GROUP SYMBOLS	TYPICAL NAMES
COARSE GRAINED SOILS 50% or more retained on the No. 200 sieve.	GRAVELS More than half of coarse fraction retained on the No. 4 sieve.	Clean gravels	GW	Well-graded gravels, gravel-sand mixtures, little or no fines.
			GP	Poorly-graded gravels, gravel-sand mixtures, little or no fines.
		Gravels with fines	GM	Silty gravels, gravel-sand mixtures.
			GC	Clayey gravels, gravel-sand-clay mixtures.
	SANDS More than half of coarse fraction passing the No. 4 sieve.	Clean sands	SW	Well-graded sands, gravelly sands, little or no fines.
			SP	Poorly-graded sands, gravelly sands, little or no fines.
		Sands with fines	SM	Silty sands, sand-silt mixtures.
			SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS More than 50% passing the No. 200 sieve.	SILTS AND CLAYS	Liquid Limit below 50%	ML	Inorganic silts and very fine sands, rock flour, silty fine sands or silts. Plasticity below "A" line.
			CL	Inorganic clays, gravelly clays, sandy clays, lean clays. Plasticity above "A" line.
			OL	Organic silts and organic clays. Plasticity below "A" line.
		Liquid Limit 50% and above	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts. Plasticity below "A" line.
			CH	Inorganic fat clays. Plasticity above "A" line.
			OH	Organic clays or organic silts. Plasticity below "A" line.
Highly organic soils			Pt	Peat, organic content greater than 60%.

LEGEND:

- ● ■ Location of Exploration.
- GR Gravel, percent by weight passing 3-inch sieve and retained on the No. 4 sieve.
- SA Sands, percent by weight passing the No. 4 sieve and retained on the No. 200 sieve.
- FI Fines, percent by weight passing the No. 200 sieve.
- LL Liquid Limit.
- PI Plasticity index (Liquid Limit Minus Plastic Limit).
- MC Field Moisture Content in Percent of Dry Weight.
- (F.C.) Visual Field Classification.
- * Laboratory Visual Classification.
- G_s Specific Gravity. (Minus No. 4)
- ⊙ Proposed Future Explorations

NOTES:

1. Classifications are in accordance with the Unified Soils Classification System (ASTM D-2487).
2. All sieve sizes on the chart are U.S. Standard.
3. The terms "silt" and "clay" are used respectively to distinguish materials exhibiting lower plasticity from those with higher plasticity. The minus No. 200 sieve material is silt if the liquid limit and plasticity index plot below the "A" line on the plasticity chart (ASTM D-2487) and is clay if the liquid limit and plasticity index plot above the "A" line on the chart.
4. Borderline Classification: Soils possessing characteristics of two groups are designated by combinations of group symbols. For example GW-GC, a well-graded gravel-sand mixture with a clay binder.
5. Trenches 4B-17 through 4B-19 were dug with a backhoe on 10 August 1983.
6. For additional explorations in the Pup Creek Detention Basin area, see Sheet No. P10.
7. Groundwater was not encountered during exploration program.



LOCATION MAP
Scale: 1" = 800'

GRAPHIC SCALE

1" = 5': 0, 1', 2', 3', 4', 5', 10', 15', 20', 25'

1" = 800': 0, 400', 800', 1600', 2400', 3200', 4000'

REVISION	DATE	DESCRIPTION	BY	BY
△				
△				

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DESIGNED: K. SWANSON
DRAWN: K. WAHL/J. HAYES
CHECKED: D. ANDERSON

REDBANK AND FANCHER CREEKS, CALIFORNIA
PUP CREEK
PUP CREEK DETENTION BASIN
LOGS OF EXPLORATIONS
4B-17 thru 4B-19

SUBMITTED: [signature]
CHIEF, SOILS DESIGN SECTION
DATE APPROVED: 4/-/86
SCALE:
SPEC. No.
SHEET P6 / 88
FILE No. SJ-11-20-11

2 F - 6

EL. 375.0

Depth	Group	N	GR	SA	FI	LL	PI	MC	Description
0 – 3.0'	SC	29	-	-	-	-	-	-	*CLAYEY SAND, reddish-brown, damp, est. 65% graded sand, est. 35% medium plasticity fines, traces of fine gravel
3.0' – 5.0'	SM	A	25	58	17	-	-	4	SILTY GRAVELLY SAND, light brown, graded angular to subrounded sand, subrounded gravel to 1" maximum, slightly cemented
5.0' – 9.0'	SM	N, 85	-	80	40	26	4	-	SILTY SAND, light brown to medium yellowish-brown, damp, very fine to medium grained sand, slightly cemented, G_s = 2.74
9.0' – 11.0'	SM-SC	R	-	63	37	25	5	10	SILTY CLAYEY SAND, medium yellowish-brown, very fine to medium grained sand, non-cemented, micaceous
11.0' – 14.5'	CL	25, 35	-	-	-	-	-	-	*SANDY CLAY, reddish-brown, damp, est. 60% medium plasticity fines, est. 40% fine grained sand, micaceous

2 F - 7

EL. 374.0

Depth	Group	N	GR	SA	FI	LL	PI	MC	Description
0 – 3.0'	ML	48	5	41	54	30	7	14	SANDY SILT, medium yellowish-brown, very fine to medium grained sand, gravel to 3/4" maximum, non-cemented
3.0' – 7.0'	SC	35, 28	-	-	-	-	-	-	*CLAYEY SAND, yellowish-red, damp, est. 80% fine grained sand, est. 40% medium plasticity fines, non-cemented, micaceous
7.0' – 12.3'	SC	37, 56, 33	-	51	49	28	11	-	CLAYEY SAND, medium yellowish-brown, damp, very fine to medium grained sand, non-cemented
12.3' – 13.0'	CL		-	-	-	-	-	-	*SANDY CLAY, yellowish-brown, damp, est. 85% medium plasticity fines, est. 15% fine grained sand, non-cemented
13.0' – 14.5'	CL	37	-	35	65	-	-	20	SANDY CLAY, medium yellowish-brown, low to medium plasticity fines, very fine to medium grained sand, non-cemented

Vertical Scale: 1" = 2'

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			GROUP SYMBOLS	TYPICAL NAMES
COARSE GRAINED SOILS 50% or more retained on the No. 200 sieve.	GRAVELS More than half of coarse fraction retained on the No. 4 sieve.	Clean gravels	G W	Well-graded gravels, gravel-sand mixtures, little or no fines.
			G P	Poorly-graded gravels, gravel-sand mixtures, little or no fines.
		Gravels with fines	G M	Silty gravels, gravel-sand mixtures.
			G C	Clayey gravels, gravel-sand-clay mixtures.
	SANDS More than half of coarse fraction passing the No. 4 sieve.	Clean sands	S W	Well-graded sands, gravelly sands, little or no fines.
			S P	Poorly-graded sands, gravelly sands, little or no fines.
		Sands with fines	S M	Silty sands, sand-silt mixtures.
			S C	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS More than 50% passing the No. 200 sieve.	SILTS AND CLAYS	Liquid Limit below 50%	M L	Inorganic silts and very fine sands, rock flour, silty fine sands or silts. Plasticity below "A" line.
			C L	Inorganic clays, gravelly clays, sandy clays, lean clays. Plasticity above "A" line.
			O L	Organic silts and organic clays. Plasticity below "A" line.
		Liquid Limit 50% and above	M H	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts. Plasticity below "A" line.
			C H	Inorganic fat clays. Plasticity above "A" line.
			O H	Organic clays or organic silts. Plasticity below "A" line.
Highly organic soils			P t	Peat, organic content greater than 60%.

STANDARD PENETROMETER DESCRIPTIVE DATA

COHESIONLESS		COHESIVE	
Blows*	Relative Density	Blows*	Consistency
0-4	Very Loose	0-1	Very Soft
5-10	Loose	2-4	Soft
11-20	Firm	5-8	Firm
21-30	Very Firm	9-15	Stiff
31-50	Dense	16-30	Very Stiff
51+	Very Dense	31+	Hard

*Blows per 1.0 ft. of penetration of a 2-inch O.D. and 1⅜-inch I.D. sampler driven by a 140-lb. hammer, 30-inch freefall.

LEGEND:

- G_s Specific Gravity. (Minus no. 4)
- GR Gravel, percent by weight passing 3-inch sieve and retained on the No. 4 sieve.
- SA Sands, percent by weight passing the No. 4 sieve and retained on the No. 200 sieve.
- FI Fines, percent by weight passing the No. 200 sieve.
- LL Liquid Limit.
- PI Plasticity Index (Liquid Limit Minus Plastic Limit).
- MC Field Moisture Content in Percent of Dry Weight.
- * Laboratory Visual Classification.
- N Number of Blows of Standard Penetrometer.
- R Refusal with Standard Penetrometer.
- A Attempt with Standard Penetrometer.

NOTES:

1. Classifications are in accordance with the Unified Soils Classification System (ASTM D-2487).
2. All sieve sizes on the chart are U.S. Standard.
3. The terms "silt" and "clay" are used respectively to distinguish materials exhibiting lower plasticity from those with higher plasticity. The minus No. 200 sieve material is silt if the liquid limit and plasticity index plot below the "A" line on the plasticity chart (ASTM D-2487) and is clay if the liquid limit and plasticity index plot above the "A" line on the chart.
4. Borderline Classification: Soils possessing characteristics of two groups are designated by combinations of group symbols. For example GW-GC, a well-graded gravel-sand mixture with a clay binder.
5. Borings 2F-6 and 2F-7 were drilled with a Mobile B-80 drill rig equipped with a 6-1/2-inch hollow stem auger on 1 September 1983.
6. For additional logs of explorations in the Pup Creek Detention Basin area, see sheet No. P6.
7. For location of explorations, see sheet No. P6.
8. Groundwater was not encountered during drilling.

GRAPHIC SCALE

1" = 2'   0 1' 2' 4' 6' 8' 10'

NOTES (Continued):

9. Refusal of the Standard Penetrometer is defined as one of the following:
   a. 25 blows for 1" or less advancement of sampler; or
   b. 50 blows for 1" to 6" advancement of sampler.
10. Attempt with the Standard Penetrometer is defined as refusal within the first 6"; seating penetration.

REVISION	DATE	DESCRIPTION	BY	BY
△				
△				

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

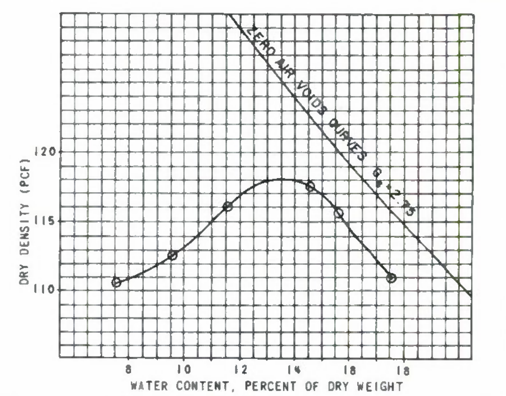
DESIGNED: N. SWANSON
DRAWN: N. WAHL/J. HAYES
CHECKED: D. ANDERSON

REDBANK AND FANCHER CREEKS, CALIFORNIA
PUP CREEK
PUP CREEK DETENTION BASIN
LOGS OF EXPLORATIONS
2F-6 and 2F-7

SUBMITTED: CHIEF, SOILS DESIGN SECTION
DATE APPROVED:
SCALE:
SPEC. No.
SHEET P7 / 89
FILE No. SJ-11-20-11

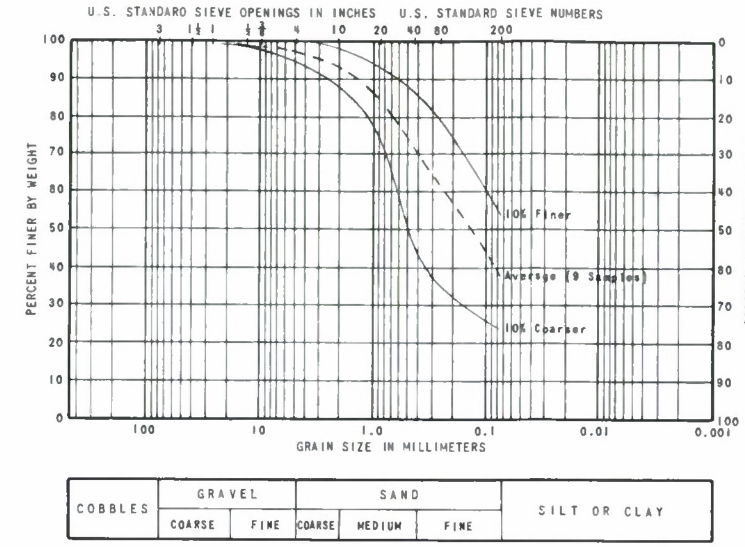
ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING

COMPACTION

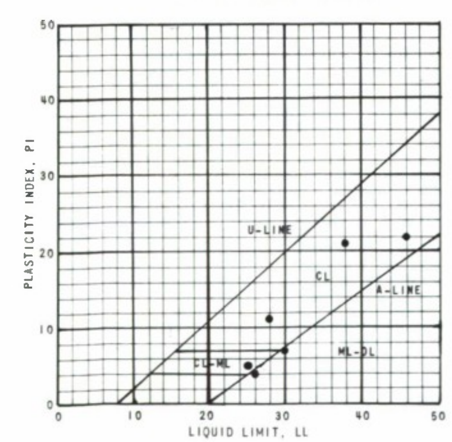


SYMBOL AND BORING NO.	MATERIAL	DEPTH (Feet)	SPECIFIC GRAVITY	ATTERBERG LIMITS LL	ATTERBERG LIMITS PI	OPTIMUM WATER CONTENT (%)	MAXIMUM DRY DENSITY (PCF)	SAMPLE CONTENT
⊙ 46-17	CLAYEY SAND (SC)	3.5-10.5	2.75	48	22	13.7	118.1	75% SA 24% FI 1% GR

GRADATION



ATTERBERG LIMITS



ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING

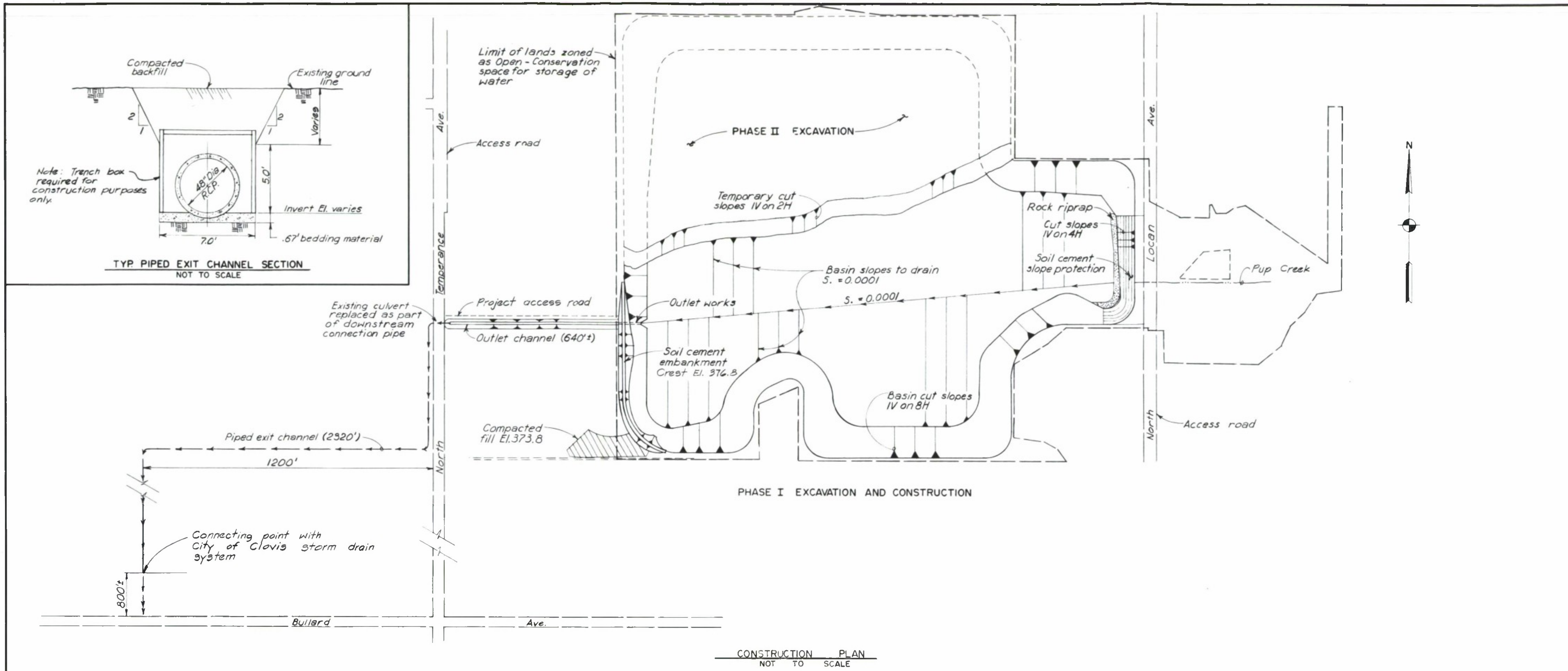
REVISION	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

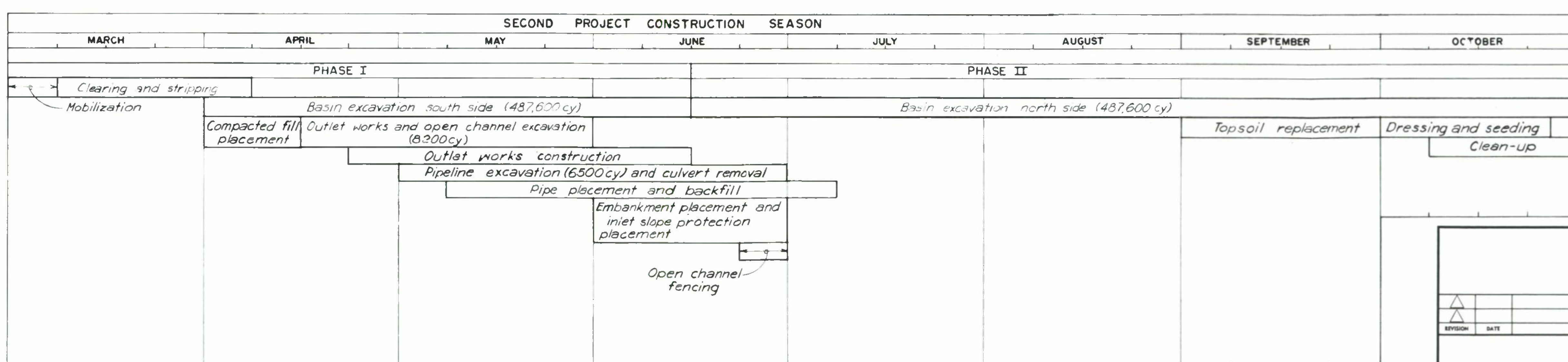
DESIGNED: K Swanson
DRAWN: K Wahl
CHECKED: D Anderson

REDBANK AND FANCHER CREEKS, CALIFORNIA
PUP CREEK
PUP CREEK DETENTION BASIN
SUMMARY OF TEST RESULTS

SUBMITTED: CHIEF, SOILS DESIGN SECTION
DATE APPROVED:
SCALE:
SHEET P8 90
FILE No. SJ-11-20-11
SPEC. No.



CONSTRUCTION PLAN
NOT TO SCALE



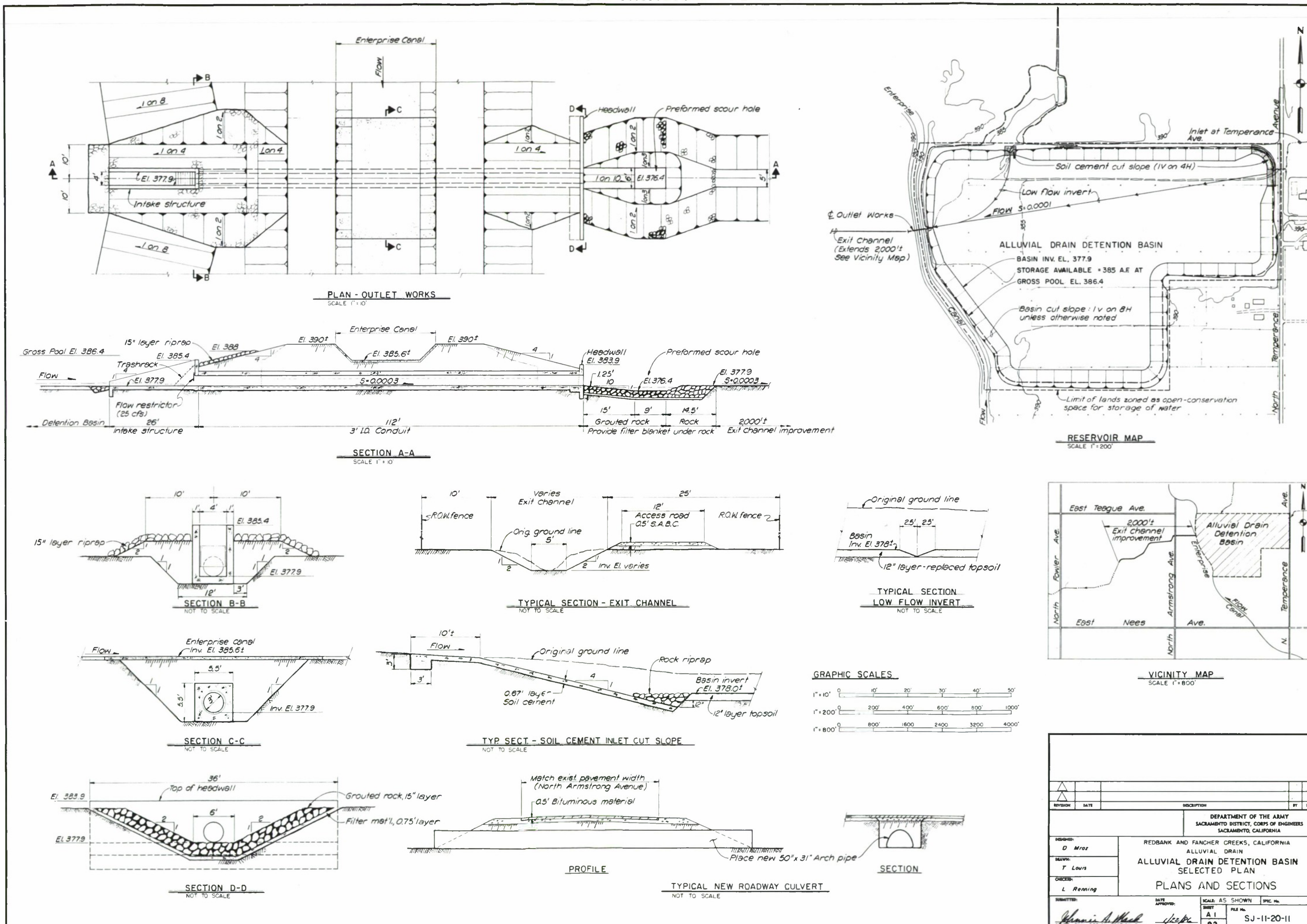
REVISION	DATE	DESCRIPTION	BY	BY

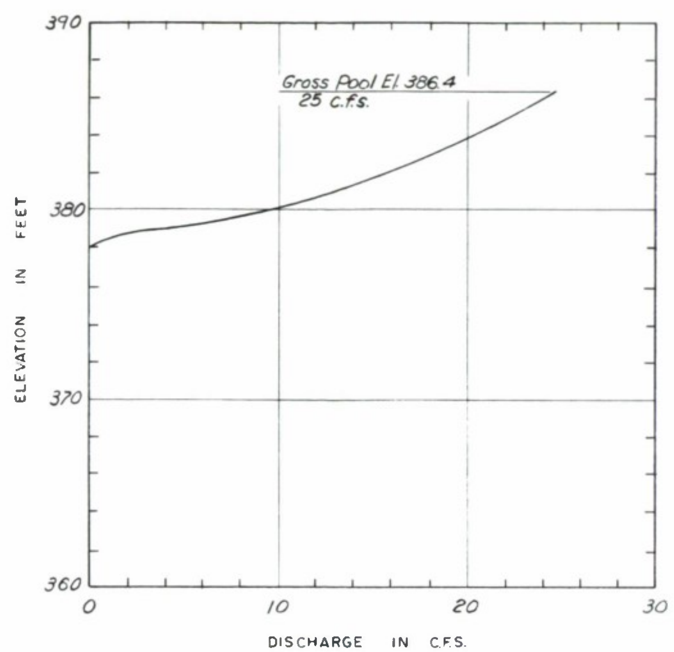
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DESIGNED: J. Slota
DRAWN: J. Cano
CHECKED: L. Reining

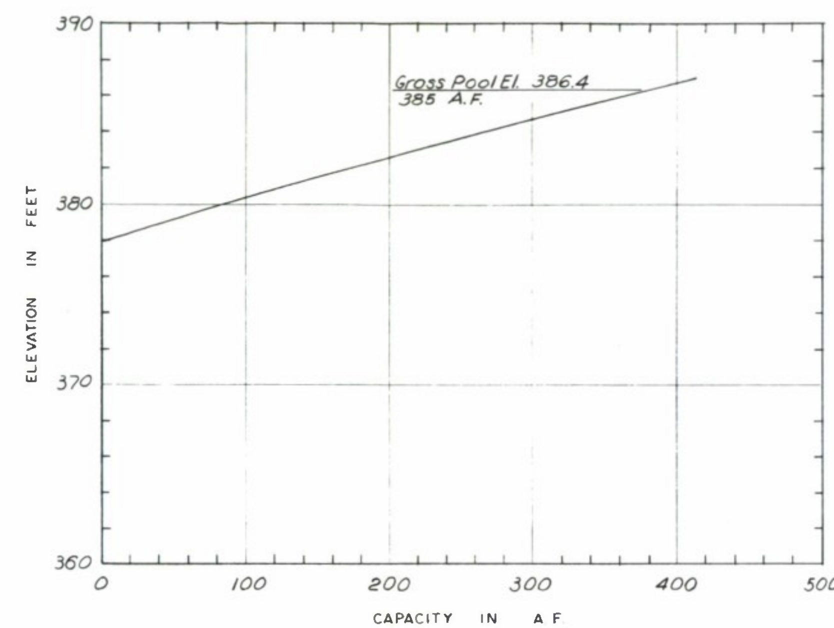
REDBANK AND FANCHER CREEKS, CALIFORNIA
PUP CREEK
PUP CREEK DETENTION BASIN
CONSTRUCTION PLAN
AND SEQUENCE

SUBMITTED: Johnnie A. Mack
CHIEF, CIVIL DESIGN SECTION B
DATE APPROVED: 4/22/86
SCALE: AS SHOWN
SHEET P9 91
SPEC. No.
FILE No. SJ-11-20-11

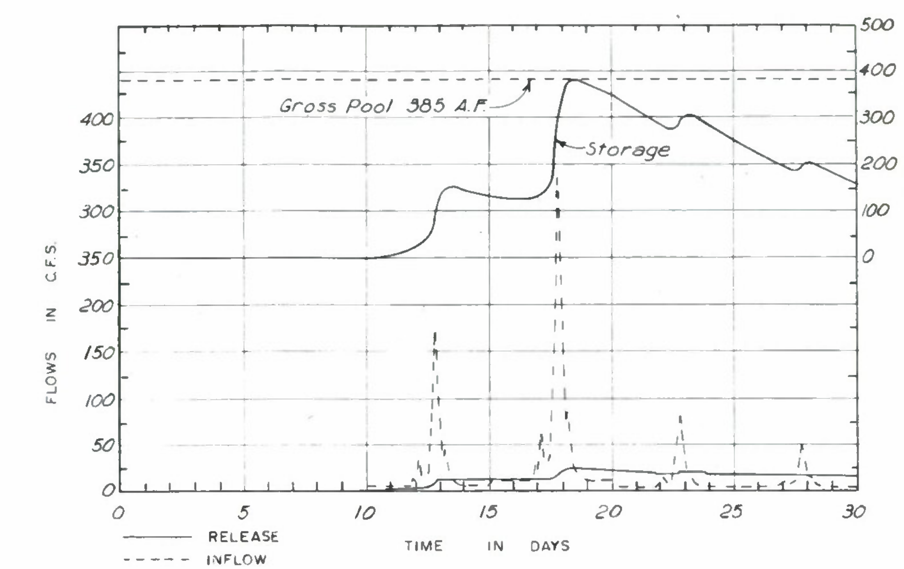

PLAN - OUTLET WORKS
SCALE 1" = 10'
SECTION A-A
SCALE 1" = 10'
RESERVOIR MAP
SCALE 1" = 200'
ALLUVIAL DRAIN DETENTION BASIN
BASIN INV. EL. 377.9
STORAGE AVAILABLE ±385 A.F. AT
GROSS POOL EL. 386.4
Basin cut slope: 1 v on 8H unless otherwise noted
Soil cement cut slope (1V on 4H)
Low flow invert
Inlet at Temperance Ave.
Limit of lands zoned as open-conservation space for storage of water
Exit Channel (Extends 2,000'± See Vicinity Map)
VICINITY MAP
SCALE 1" = 800'
SECTION B-B
NOT TO SCALE
TYPICAL SECTION - EXIT CHANNEL
NOT TO SCALE
TYPICAL SECTION LOW FLOW INVERT
NOT TO SCALE
SECTION C-C
NOT TO SCALE
TYP SECT - SOIL CEMENT INLET CUT SLOPE
NOT TO SCALE
GRAPHIC SCALES
SECTION D-D
NOT TO SCALE
PROFILE
TYPICAL NEW ROADWAY CULVERT
NOT TO SCALE
SECTION
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
REDBANK AND FANCHER CREEKS, CALIFORNIA
ALLUVIAL DRAIN
ALLUVIAL DRAIN DETENTION BASIN
SELECTED PLAN
PLANS AND SECTIONS
DESIGNED: D Mroz
DRAWN: T Louis
CHECKED: L Renning
SCALE: AS SHOWN
SHEET A1 92
SJ-11-20-11



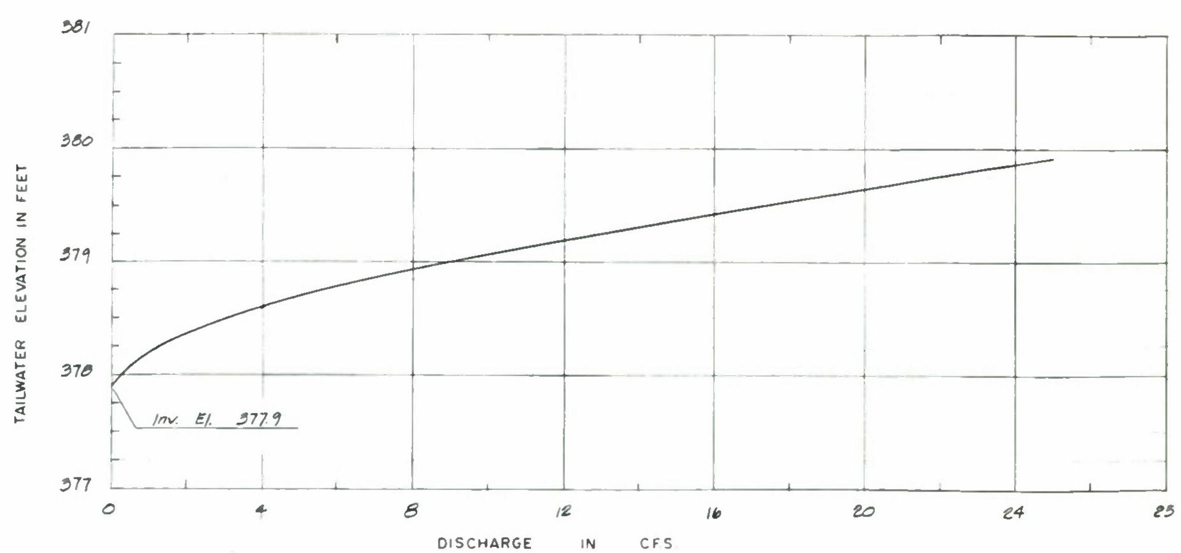
OUTLET WORKS DISCHARGE RATING CURVE



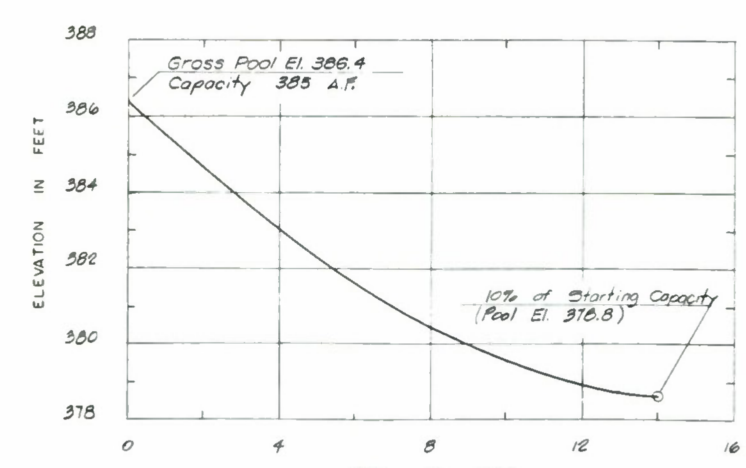
CAPACITY CURVE



BASIN DESIGN FLOOD (200-YEAR) ROUTING CURVE



OUTLET WORKS TAILWATER RATING CURVE



BASIN LOW LEVEL DRAWDOWN CURVE

NOTE
1. Elevations refer to the National Geodetic Vertical Datum of 1929.

REVISION	DATE	DESCRIPTION	BY	BY

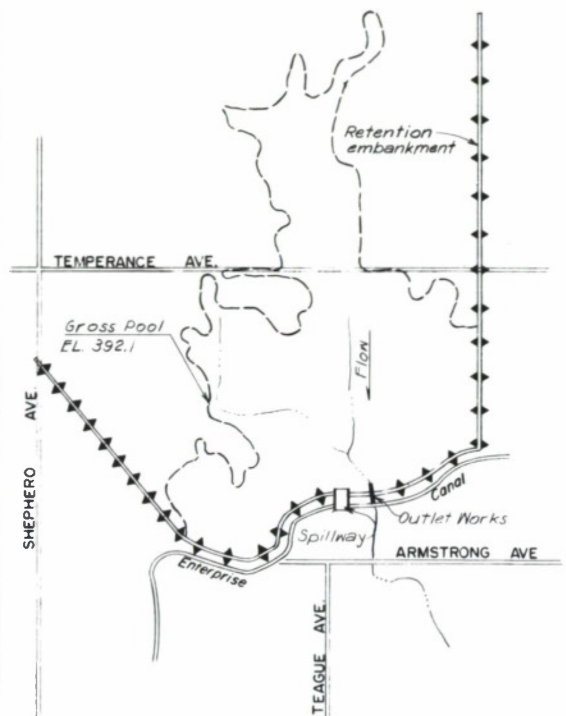
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DESIGNED: W O'Leary
DRAWN: J. Cano
CHECKED: S.C. Chen
SUBMITTED: Harold C. Huff
CHIEF, HYDRAULIC DESIGN SECTION

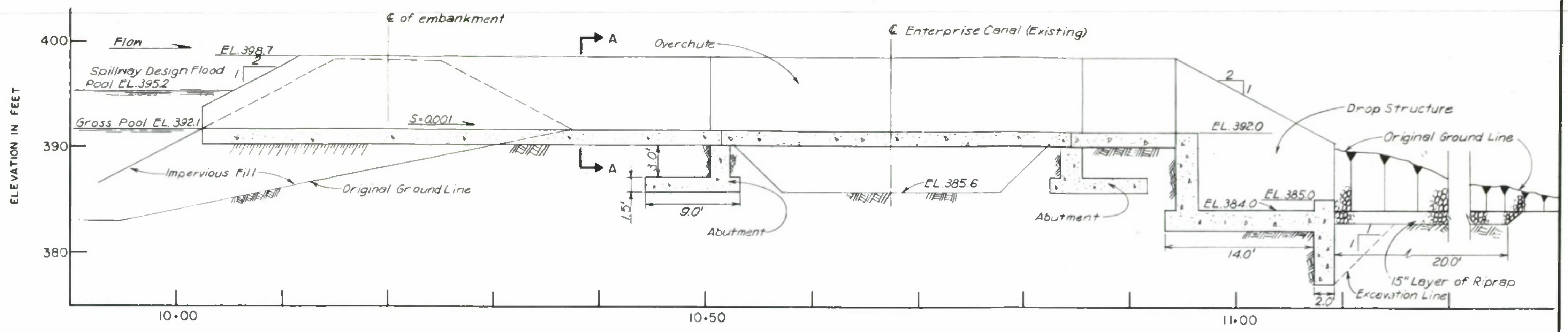
REDBANK AND FANCHER CREEKS, CALIFORNIA
ALLUVIAL DRAIN
ALLUVIAL DRAIN DETENTION BASIN

HYDRAULIC DATA

DATE APPROVED: 22 JAN 86
SCALE: AS SHOWN
SHEET A2 93
FILE No. SJ-11-20-11

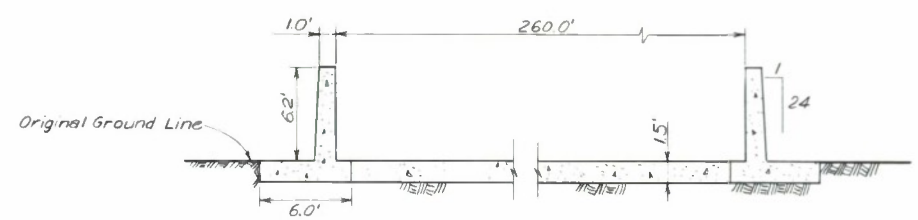


RESERVOIR MAP
0 500' 1000'

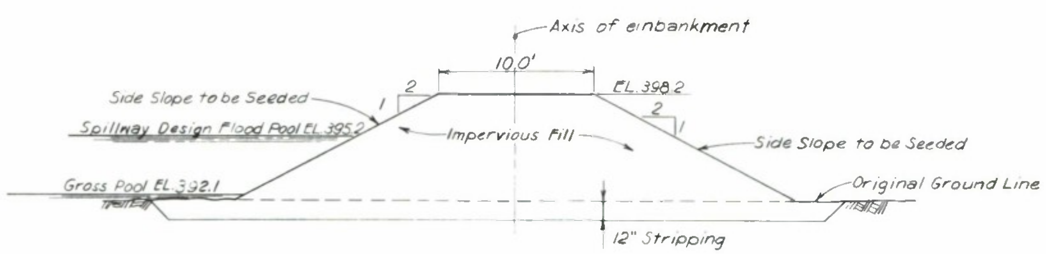


STATIONS IN FEET

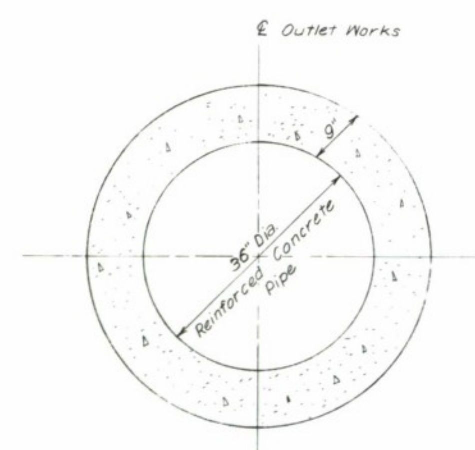
PROFILE ALONG ℄ OF SPILLWAY
SCALE 1" = 5'



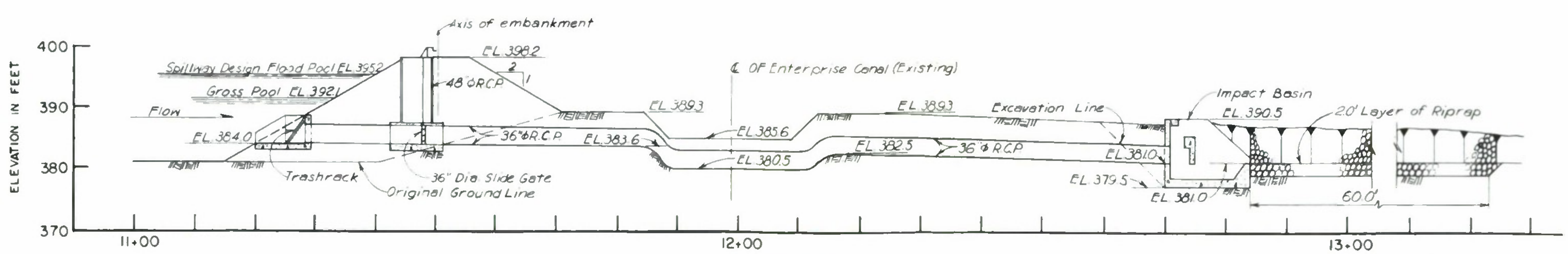
SECTION A-A
SCALE 1" = 5'-0"



TYPICAL EMBANKMENT SECTION
SCALE 1" = 5'-0"



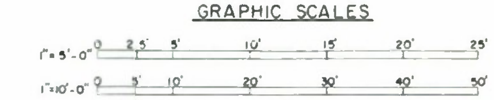
TYPICAL CONDUIT SECTION
SCALE 1" = 1'



STATIONS IN FEET

PROFILE ALONG ℄ OF OUTLET WORKS
SCALE 1" = 10'

GRAPHIC SCALES



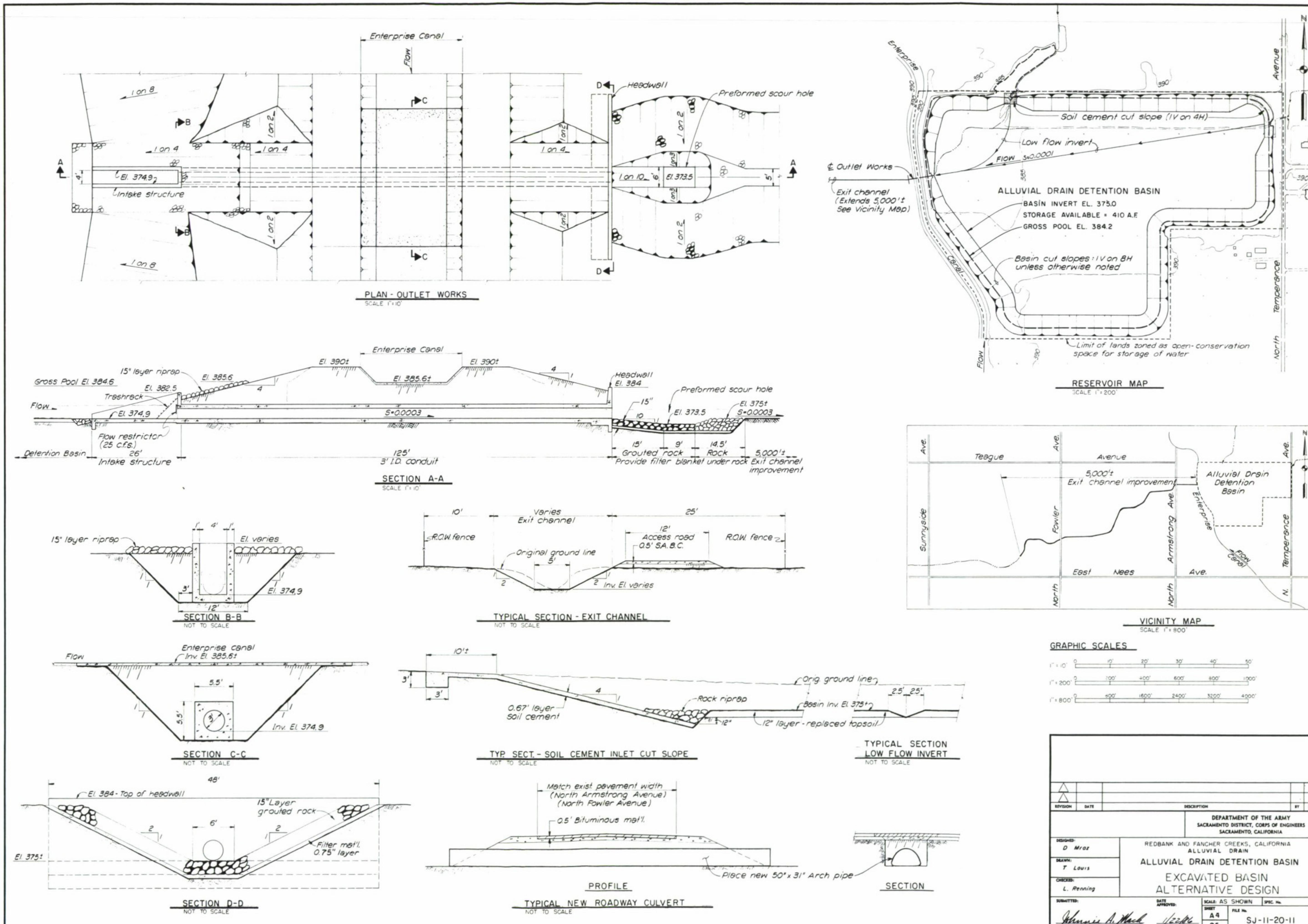
REVISION	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

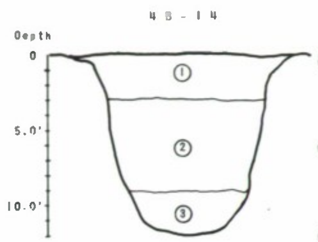
DESIGNED: D. Mraz
DRAWN: J. Cano
CHECKED: L. Renning
SUBMITTED: Johnnie A. Wack
CHIEF, CIVIL DESIGN, SECTION B

REDBANK AND FANCHER CREEKS, CALIFORNIA
ALLUVIAL DRAIN
ALLUVIAL DRAIN DETENTION BASIN
MODIFIED FEASIBILITY
BASIN ALTERNATIVE

DATE APPROVED: 1/22/86
SCALE: AS SHOWN
SHEET: A3 94
FILE No.: SJ-11-20-11


PLAN - OUTLET WORKS
SCALE 1"=10'
Enterprise Canal
Flow
Headwall
Preformed scour hole
1 on 8
1 on 4
1 on 2
1 on 10
El. 374.9
Intake structure
El. 373.5
SECTION A-A
SCALE 1"=10'
Gross Pool El. 384.6
15" layer riprap
El. 385.6
El. 382.5
Trashrack
El. 374.9
Flow restrictor (25 c.f.s.)
Detention Basin
26' Intake structure
El. 390±
El. 385.6±
S=0.0003
125' 3' I.D. conduit
Headwall El. 384
El. 373.5
El. 375± S=0.0003
15' Grouted rock
9'
14.5' Rock
5,000'± Exit channel improvement
Provide filter blanket under rock
RESERVOIR MAP
SCALE 1"=200'
ALLUVIAL DRAIN DETENTION BASIN
BASIN INVERT EL. 375.0
STORAGE AVAILABLE = 410 A.F.
GROSS POOL EL. 384.2
Soil cement cut slope (1V on 4H)
Low flow invert
FLOW S=0.0001
℄ Outlet Works
Exit channel (Extends 5,000'± See Vicinity Map)
Basin cut slopes: 1V on 8H unless otherwise noted
Limit of lands zoned as open-conservation space for storage of water
Enterprise Canal
Avenue
North Temperance
VICINITY MAP
SCALE 1"=800'
Teague Ave.
Sunnyside Ave.
North Fowler Ave.
North Armstrong Ave.
East Nees Ave.
5,000'± Exit channel improvement
Alluvial Drain Detention Basin
Enterprise Canal
GRAPHIC SCALES
1"=10' 0 10' 20' 30' 40' 50'
1"=200' 0 200' 400' 600' 800' 1000'
1"=800' 0 800' 1600' 2400' 3200' 4000'
SECTION B-B
NOT TO SCALE
15" layer riprap
El. varies
4'
3'
12'
El. 374.9
TYPICAL SECTION - EXIT CHANNEL
NOT TO SCALE
10'
Varies Exit channel
25'
R.O.W. fence
Original ground line
5'
Inv. El. varies
12' Access road 0.5' S.A.B.C.
SECTION C-C
NOT TO SCALE
Flow
Enterprise canal Inv. El. 385.6±
5.5'
3'
Inv. El. 374.9
TYP. SECT. - SOIL CEMENT INLET CUT SLOPE
NOT TO SCALE
10'±
3'
0.67' layer Soil cement
Rock riprap
Orig. ground line
Basin Inv. El. 375±
12"
12" layer - replaced topsoil
TYPICAL SECTION LOW FLOW INVERT
NOT TO SCALE
25' 25'
SECTION D-D
NOT TO SCALE
48'
El. 384 - Top of headwall
15" Layer grouted rock
6'
Filter mat'l. 0.75" layer
El. 375±
PROFILE
TYPICAL NEW ROADWAY CULVERT
NOT TO SCALE
Match exist pavement width (North Armstrong Avenue) (North Fowler Avenue)
0.5' Bituminous mat'l.
Place new 50"x 31" Arch pipe
SECTION
REVISION DATE DESCRIPTION BY
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
DESIGNED: D. Mroz
DRAWN: T. Louis
CHECKED: L. Renning
REDBANK AND FANCHER CREEKS, CALIFORNIA
ALLUVIAL DRAIN
ALLUVIAL DRAIN DETENTION BASIN
EXCAVATED BASIN
ALTERNATIVE DESIGN
SUBMITTED: Johnnie A. Black
CHIEF, CIVIL DESIGN SECTION B
DATE APPROVED:
SCALE: AS SHOWN
SHEET A4 95
FILE No. SJ-11-20-11

4B-14

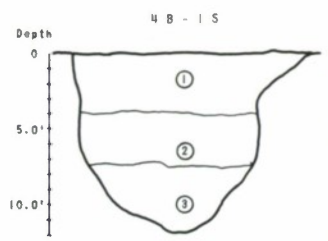


① SANDY SILT (ML), medium to light brown, dry to damp, est. 60% low plasticity fines, est. 40% very fine to fine grained sand, firm to stiff, slightly cemented, brittle (F.C.)

② CLAYEY SAND (SC), yellowish-red, moist, 78% graded angular to sub-angular grained sand, 22% medium plasticity fines, traces of fine gravel, slightly cemented in pieces, breaks down fairly easy

③ CLAYEY SAND (SC), medium yellowish-brown, 3% moisture content, 87% very fine to medium grained sand, 33% low plasticity fines (LL = 28, PI = 14), firm to dense, non-to slightly cemented. G_s = 2.75

4B-15

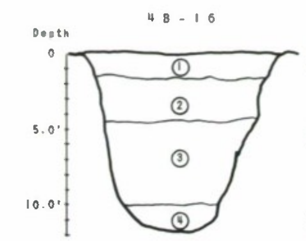


① SILTY SAND (SM), greyish-brown to greyish-red with iron oxide staining, 10% moisture content, 67% graded sand, 33% low plasticity fines, firm to very stiff, brittle

② CLAYEY SAND (SC), medium brown to medium reddish-brown, 8% moisture content, 81% graded subangular to round grained sand, 19% low plasticity fines (LL = 28, PI = 8), firm to very firm, slightly cemented

③ *CLAYEY SAND (SP-SC), yellowish-red, moist, est. 90% graded angular to subangular grained sand, est. 10% medium plasticity fines, traces of fine gravel, firm, breaks down easily

4B-16



① SANDY SILT (ML), dark yellowish-brown, dry, est. 70% low plasticity fines, est. 30% very fine to fine grained sand, abundant organic material (grass, roots, etc.), stiff, brittle (F.C.)

② SANDY CLAY (CL), medium to dark yellowish-brown, 15% moisture content, 57% low plasticity fines (LL = 29, PI = 11), 43% very fine to medium grained sand, firm to stiff, breaks down easily, micaceous, G_s = 2.75

③ CLAYEY SAND (SC), light brown to medium yellowish-brown, damp to moist, 58% very fine to medium grained sand, 42% low plasticity fines, loose to firm, non- to slightly cemented, breaks down easily

④ *CLAYEY SAND (SC), yellowish-red, moist, est. 70% graded sand, est. 30% medium plasticity fines, traces of fine gravel, loose to firm, non- to slightly cemented

Scale: 1" = 5'

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			GROUP SYMBOLS	TYPICAL NAMES
COARSE GRAINED SOILS 50% or more retained on the No. 200 sieve.	GRAVELS More than half of coarse fraction retained on the No. 4 sieve.	Clean gravels	GW	Well-graded gravels, gravel-sand mixtures, little or no fines.
			GP	Poorly-graded gravels, gravel-sand mixtures, little or no fines.
		Gravels with fines	GM	Silty gravels, gravel-sand mixtures.
			GC	Clayey gravels, gravel-sand-clay mixtures.
	SANDS More than half of coarse fraction passing the No. 4 sieve.	Clean sands	SW	Well-graded sands, gravelly sands, little or no fines.
			SP	Poorly-graded sands, gravelly sands, little or no fines.
		Sands with fines	SM	Silty sands, sand-silt mixtures.
			SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS More than 50% passing the No. 200 sieve.	SILTS AND CLAYS	Liquid Limit below 50%	ML	Inorganic silts and very fine sands, rock flour, silty fine sands or silts. Plasticity below "A" line.
			CL	Inorganic clays, gravelly clays, sandy clays, lean clays. Plasticity above "A" line.
			OL	Organic silts and organic clays. Plasticity below "A" line.
		Liquid Limit 50% and above	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts. Plasticity below "A" line.
			CH	Inorganic fat clays. Plasticity above "A" line.
			OH	Organic clays or organic silts. Plasticity below "A" line.
Highly organic soils			Pt	Peat, organic content greater than 50%.

LOCATION MAP
Scale: 1" = 800'

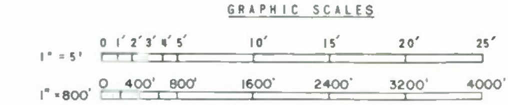
LEGEND:

- ● ■ Location of Exploration.
- GR Gravel, percent by weight passing 3-inch sieve and retained on the No. 4 sieve.
- SA Sands, percent by weight passing the No. 4 sieve and retained on the No. 200 sieve.
- FI Fines, percent by weight passing the No. 200 sieve.
- LL Liquid Limit.
- PI Plasticity Index (Liquid Limit Minus Plastic Limit).
- MC Field Moisture Content in Percent of Dry Weight.
- (F.C.) Visual Field Classification.
- * Laboratory Visual Classification.
- G_s Specific Gravity. (Minus No. 4)
- ⊙ Proposed Future Explorations

NOTES:

1. Classifications are in accordance with the Unified Soils Classification System (ASTM D-2487).
2. All sieve sizes on the chart are U.S. Standard.
3. The terms "silt" and "clay" are used respectively to distinguish materials exhibiting lower plasticity from those with higher plasticity. The minus No. 200 sieve material is silt if the liquid limit and plasticity index plot below the "A" line on the plasticity chart (ASTM D-2487) and is clay if the liquid limit and plasticity index plot above the "A" line on the chart.
4. Borderline Classification: Soils possessing characteristics of two groups are designated by combinations of group symbols. For example GW-GC, a well-graded gravel-sand mixture with a clay binder.
5. Trenches 4B-14 through 4B-16 were dug with a backhoe on 11 August 1983.
6. For additional logs of explorations in the Alluvial Drain Detention Basin area, see sheet No. A6.
7. Groundwater was not encountered during trenching.

GRAPHIC SCALES



REVISION	DATE	DESCRIPTION	BY	BY
△				
△				

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DESIGNED: K. SWAPSON
DRAWN: K. KARL/J. PAYES
CHECKED: D. ANDERSON

REDBANK AND FANCHER CREEKS, CALIFORNIA
ALLUVIAL DRAIN
ALLUVIAL DRAIN DETENTION BASIN
LOGS OF EXPLORATIONS
4B-14 thru 4B-16

SUBMITTED: Chief, Soils Design Section
DATE APPROVED: 4/24/86
SCALE:
SPEC. No.
SHEET A5 96
FILE No. SJ-11-20-11

ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING

2F-8

Depth	Class	N	GR	SA	FI	LL	PI	MC	Description
EL 3904 0	SC	10, 10, 5, 5	-	-	-	-	-	11	*CLAYEY SAND, derk brown, est. 65% greded send, est. 55% medium plesticity fjnes, treces of fine grevel, non-cemented. At 7.5' depth, es ebove except wet to setureted
9.0'	SM	9	-	67	33	-	-	-	SILTY SAND, medium brown to greyjsh-brown, setureted, very fjne to medium grejned send, low plesticity fjnes, non-cemented
10.0'	SC	17	-	55	45	30	18	-	CLAYEY SAND, medium brown, wet, very fjne to medium enguler to subenguler grejned send, non-cemented, $G_s = 2.72$
15.0'	CL	26	-	-	-	-	-	-	*SANDY CLAY, reddish-grey, demp, est. 65% medium plestjcity fines, est. 55% fjne grejned send, treces of orgenic meteriel, non-cemented
15.0'	SM-SC	R	2	55	45	25	7	12	SILTY CLAYEY SAND, ljght brown with iron oxide stejning, very fjne to medium grejned send, grevel to 1/2" meximum, non-cemented, cerboneceous
16.0'	SC	77	-	-	-	-	-	-	*CLAYEY SAND, yellowjsh-red, mojst, est. 55% fine grejned send, est. 45% medjum plestjcjty fines, non-cemented, miceceous
18.5'		R	-	-	-	-	-	-	*CLAYEY SAND, yellowish-red, demp, est. 75% greded send, est. 25% medium plesticjty fines, scettered fjne grevel to 5/8" mexjmum, non-cemented
19.5'									

LEVEE FILL (0 to 10.0') — FOUNDATION (10.0' to 19.5')

2F-9

Depth	Class	N	GR	SA	FI	LL	PI	MC	Description
EL 3904 0	SC-SM	8, 5, 5	-	53	47	18	5	8	CLAYEY SILTY SAND, medjum brown, very fjne to medium grejned send, non-cemented
7.0'	SC	10	-	-	-	-	-	-	*CLAYEY SAND, reddish-brown, mojst, est. 80% fine grejned send, est, 40% medjum plestjcjty fjnes, non-cemented, miceceous
6.0'	SM	A	8	89	25	-	-	6	SILTY SAND, medium brown, graded engular tn subanguler grejned send, low plestic-ity fines, gravel to 1/2" meximum, non-cemented, grevel composed of quertz end mjce schist
11.0'	SC-SM	R, R	-	57	43	27	5	-	CLAYEY SILTY SAND, light brown, dry to demp, very fjne to medjum grejned send, non-cemented
15.5'									

LEVEE FILL (0 to 6.0') — FOUNDATION (6.0' to 15.5')

Vertical Scale: 1" = 2'

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			GROUP SYMBOLS	TYPICAL NAMES
COARSE GRAINED SOILS 50% or more retained on the No. 200 sieve.	GRAVELS More than half of coarse fraction retained on the No. 4 sieve.	Clean gravels	GW	Well-graded gravels, gravel-sand mixtures, little or no fines.
			GP	Poorly-graded gravels, gravel-sand mixtures, little or no fines.
		Gravels with fines	GM	Silty gravels, gravel-sand mixtures.
			GC	Clayey gravels, gravel-sand-clay mixtures.
	SANDS More than half of coarse fraction passing the No. 4 sieve.	Clean sands	SW	Well-graded sands, gravelly sands, little or no fines.
			SP	Poorly-graded sands, gravelly sands, little or no fines.
		Sands with fines	SM	Silty sands, sand-silt mixtures.
			SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS More than 50% passing the No. 200 sieve.	SILTS AND CLAYS	Liquid Limit below 50%	ML	Inorganic silts and very fine sands, rock flour, silty fine sands or silts. Plasticity below "A" line.
			CL	Inorganic clays, gravelly clays, sandy clays, lean clays. Plasticity above "A" line.
			OL	Organic silts and organic clays. Plasticity below "A" line.
		Liquid Limit 50% and above	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts. Plasticity below "A" line.
			CH	Inorganic fat clays. Plasticity above "A" line.
			OH	Organic clays or organic silts. Plasticity below "A" line.
Highly organic soils			Pt	Peat, organic content greater than 60%.

STANDARD PENETROMETER OESCRIPTIVE DATA

COHESIONLESS		COHESIVE	
Blows*	Relativa Density	Blows*	Consistency
0-4	Vary Loose	0-1	Vary Soft
5-10	Loose	2-4	Soft
11-20	Firm	5-8	Firm
21-30	Vary Firm	9-15	Stiff
31-50	Dense	16-30	Vary Stiff
51+	Vary Dansa	31+	Herd

*Blows per 1.0 ft. of penetration of a 2-inch O.D. and 1⅜-inch I.D. sampler driven by a 140-lb. hammer, 30-inch freefell.

LEGEND:

- G_s Specific Gravity. (Minus No. 4)
- GR Gravel, percent by weight passing 3-inch sieve and retained on the No. 4 sieve.
- SA Sands, percent by weight passing the No. 4 sie e and retained on the No. 200 sieva.
- FI Finas, percent by weight passing tha No. 200 sieve.
- LL Liquid Limit.
- PI Plasticity Index (Liquid Limit Minus Plastic Limit).
- MC Fiald Moisture Content in Percent of Dry Weight.
- * Laboratory Visual Classification.
- N Number of Blows of Stenderd Penetrometer.
- R Rafusal with Stenderd Panetrometar.
- A Attempt with Standerd Panetromatar.

NOTES:

1. Classificationa ara in accordenca with tha Unified Soils Classification System (ASTM D-2487).
2. All sieve sizes on the chart sra U.S. Standerd.
3. The tarms "silt" and "clay" era used raspectivaly to distinguish materiels axhibiting lower plasticity from those with highar plasticity. The minus No. 200 sieva matsriel is silt if tha liquid limit and plasticity indax plot below the "A" line on the plasticity chart (ASTM D-2487) and is clay if the liquid limit and plasticity index plot ebova the "A" line on the chart.
4. Borderline Classification: Soils possessing characteristics of two groupa ara designated by combinationa of group symbols. For sxampla GW-GC, a wall-graded grsvel-sand mixtura with a clay binder.
5. Borings 2F-8 and 2F-9 were drilled with a Mobile B-80 drill rig equipped with a 6-1/2-inch hollow stem auger on 1 September 1983.
6. For additional logs of explorations in the Alluvial Orain aree, see sheet No. A5.
7. For location of explorations, see sheet No. A5.
8. Groundwater wes not encountered during drilling.

GRAPHIC SCALE

1" = 2' 0 1' 2' 4' 6' 8' 10'

NOTES (Continued):

9. Refusel of the Stenderd Penetrometer is defined es one of the following:
   a. 25 blows for 1" or less edvencement of sempler; or
   b. 50 blows for 1" to 6" edvencement of sempler.
10. Attempt with the Stenderd Penetrometer is defined as refusal within the first 6": seeting penetration.

REVISION	DATE	DESCRIPTION	BY	BY
△				
△				

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DESIGNED: K. SWANSON
DRAWN: K. WAHL/J. HAYES
CHECKED: D. ANDERSON

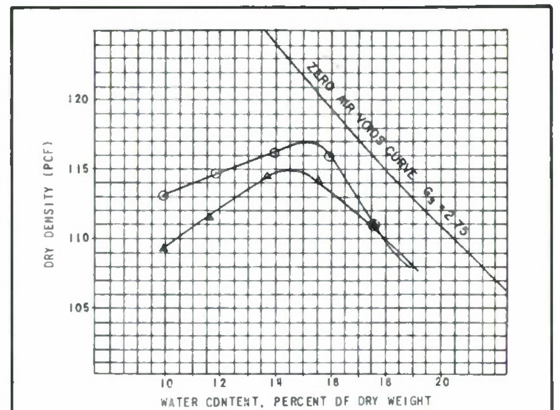
REDBANK AND FANCHER CREEKS, CALIFORNIA
ALLUVIAL DRAIN

ALLUVIAL DRAIN DETENTION BASIN
LOGS OF EXPLORATIONS
2F-8 and 2F-9

SUBMITTED: Clark E. Strange — CHIEF, SOILS DESIGN SECTION
DATE APPROVED: 4/22/86
SCALE:
SPEC. No.
SHEET A6 97
FILE No. SJ-11-20-11

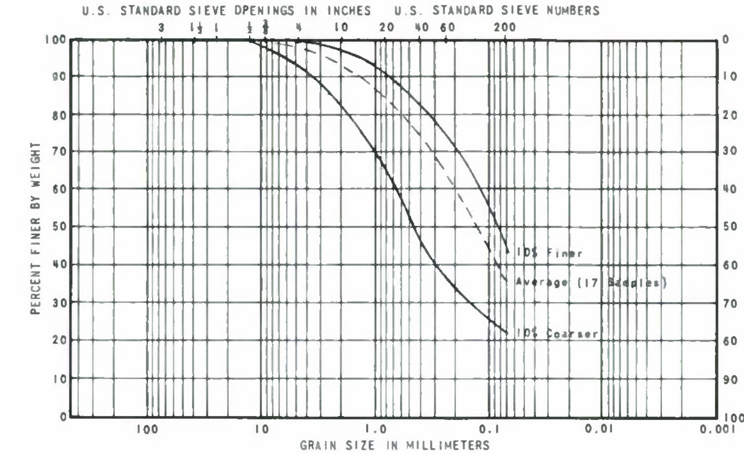
ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING

COMPACTION



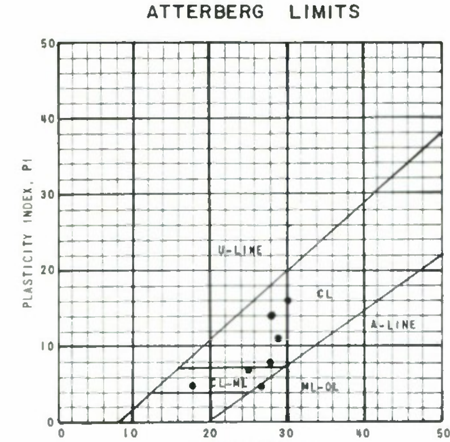
SYMBOL AND BORING NO.	MATERIAL	DEPTH (Feet)	SPECIFIC GRAVITY	ATTERBERG LIMITS LL	PI	SAMPLE CONTENT	OPTIMUM WATER CONTENT (%)	MAXIMUM DRY DENSITY (PCF)
▽ 46-16	SANDY CLAY (CL)	1.5-4.5	2.75	29	11	57% Fines 43% Sand	14.5	114.9
○ 46-14	CLAYEY SAND (SC)	9.0-12.0	2.75	26	14	33% Fines 67% Sand	15.3	117.0

GRADATION



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

ATTERBERG LIMITS



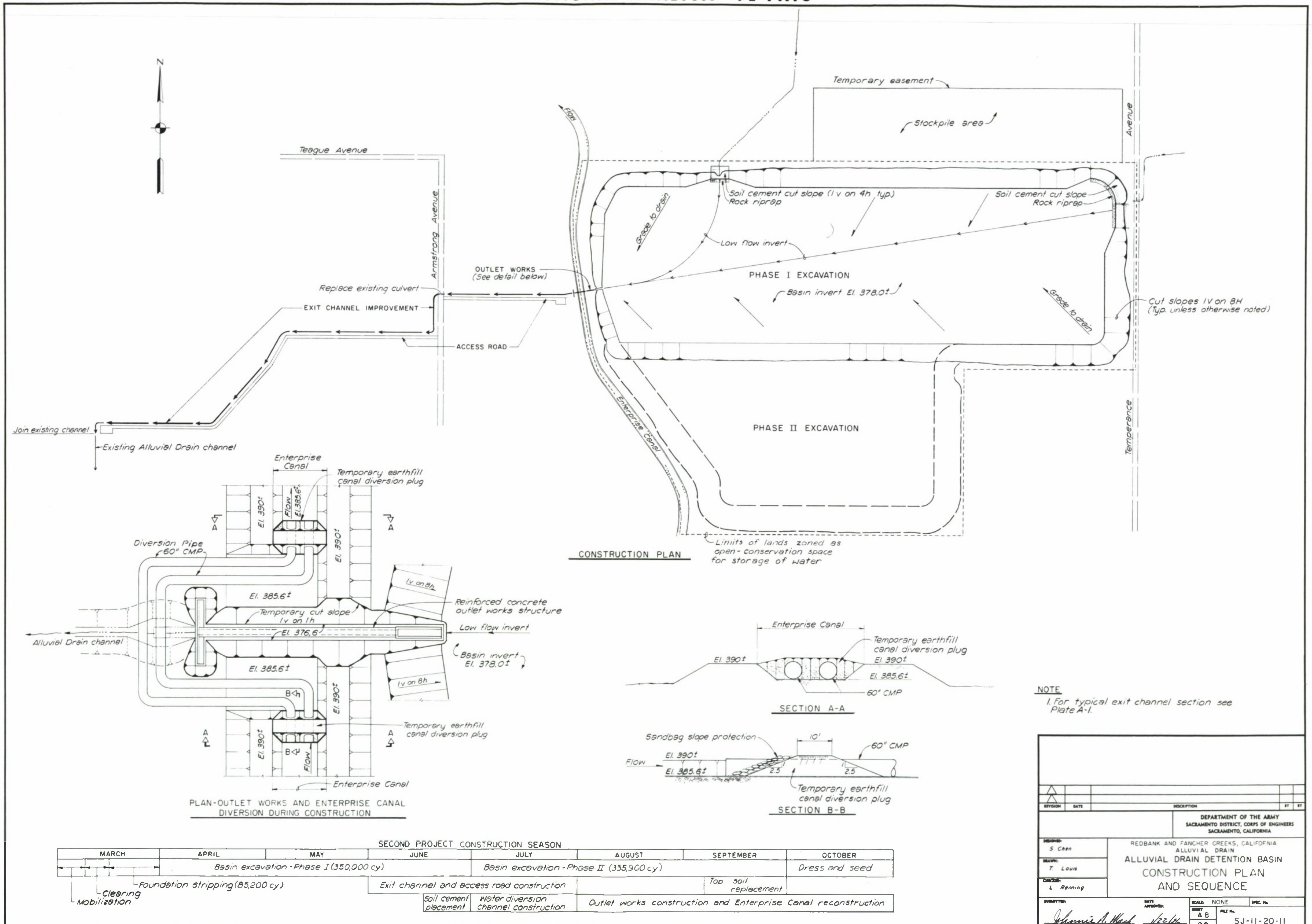
REVISION	DATE	DESCRIPTION	BY

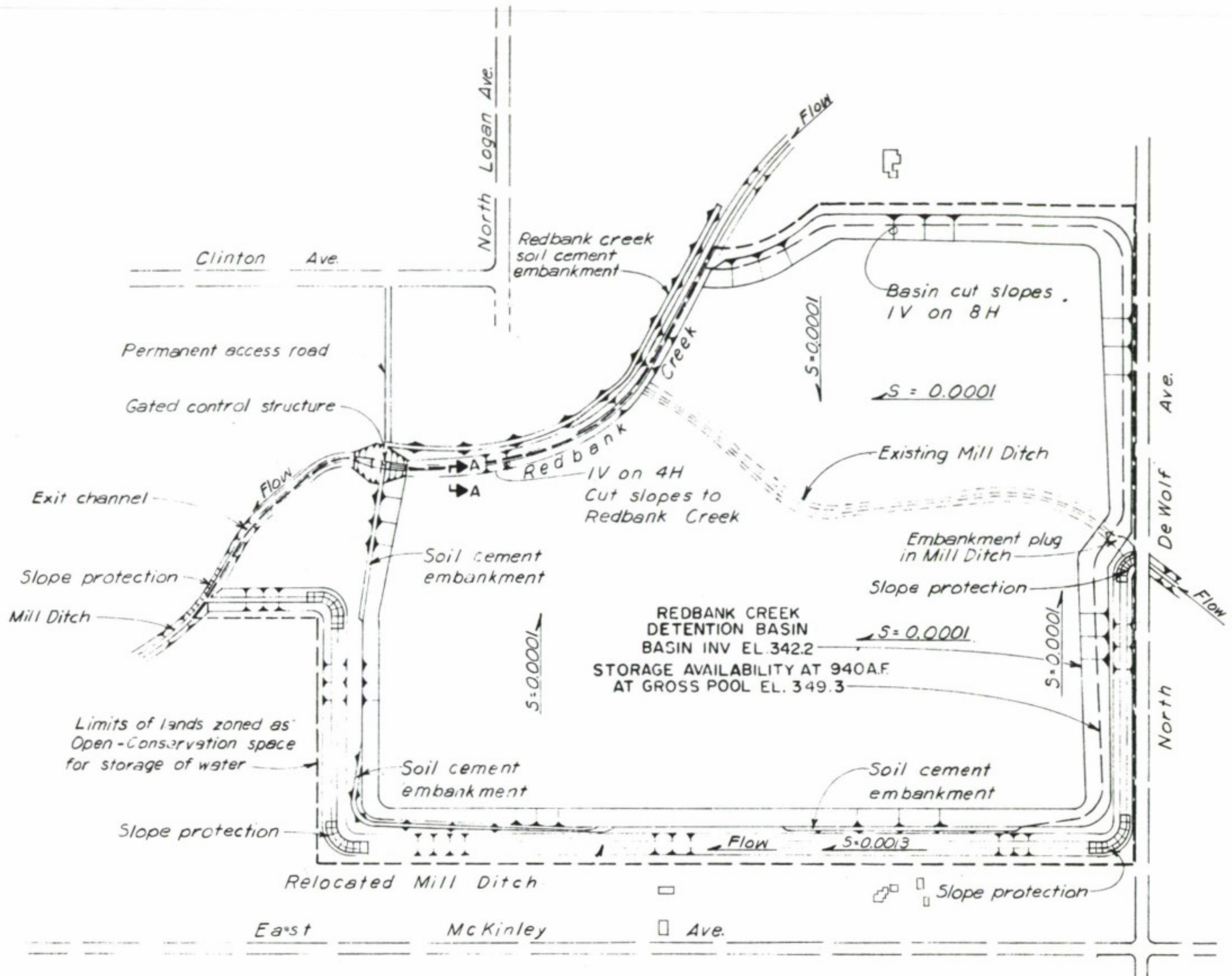
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DESIGNED: K. Swanson
DRAWN: K. Wohl/N. Wilson
CHECKED: D. Anderson
SUBMITTED: CHIEF, SOILS DESIGN SECTION

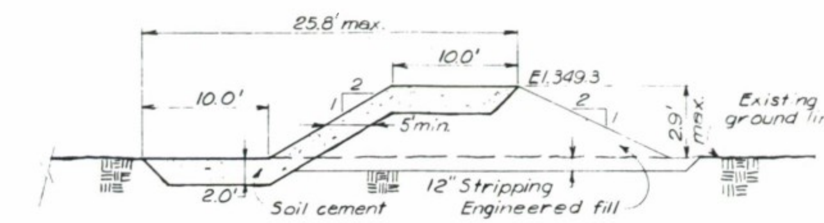
REDBANK AND FANCHER CREEKS, CALIFORNIA
ALLUVIAL DRAIN
ALLUVIAL DRAIN DETENTION BASIN
SUMMARY OF TEST RESULTS

DATE APPROVED: 4/2/86
SCALE:
SHEET A 7
98
FILE No. SJ-11-20-11
SPEC. No.

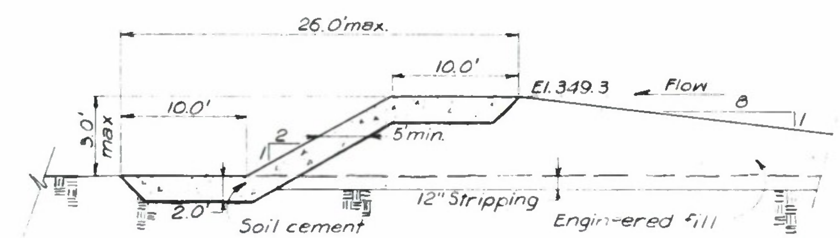

Temporary easement
Stockpile area
Avenue
Teague Avenue
Armstrong Avenue
Flow
Soil cement cut slope (1 v on 4h typ.)
Rock riprap
Soil cement cut slope
Rock riprap
Grade to drain
Low flow invert
OUTLET WORKS
(See detail below)
PHASE I EXCAVATION
Basin invert El. 378.0±
Replace existing culvert
EXIT CHANNEL IMPROVEMENT
Cut slopes 1V on 8H
(Typ. unless otherwise noted)
ACCESS ROAD
Join existing channel
Existing Alluvial Drain channel
Enterprise Canal
PHASE II EXCAVATION
Temperance
CONSTRUCTION PLAN
Limits of lands zoned as open-conservation space for storage of water
Temporary earthfill canal diversion plug
El. 390±
El. 385.6±
Diversion Pipe
60" CMP
Temporary cut slope
1v on 1h
El. 376.6
Reinforced concrete outlet works structure
Low flow invert
Basin invert
El. 378.0±
1v on 8h
Alluvial Drain channel
Flow
PLAN-OUTLET WORKS AND ENTERPRISE CANAL
DIVERSION DURING CONSTRUCTION
60" CMP
SECTION A-A
Sandbag slope protection
10'
2.5
SECTION B-B
NOTE
1. For typical exit channel section see Plate A-1.
SECOND PROJECT CONSTRUCTION SEASON
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
Basin excavation - Phase I (350,000 cy)
Basin excavation - Phase II (335,900 cy)
Dress and seed
Foundation stripping (85,200 cy)
Clearing
Mobilization
Exit channel and access road construction
Top soil replacement
Soil cement placement
Water diversion channel construction
Outlet works construction and Enterprise Canal reconstruction
REVISION
DATE
DESCRIPTION
BY
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
DESIGNED: S. Chen
DRAWN: T. Louis
CHECKED: L. Renning
SUBMITTED:
REDBANK AND FANCHER CREEKS, CALIFORNIA
ALLUVIAL DRAIN
ALLUVIAL DRAIN DETENTION BASIN
CONSTRUCTION PLAN
AND SEQUENCE
DATE APPROVED:
SCALE: NONE
SPEC. No.
SHEET
AB
99
FILE No.
SJ-11-20-11
CHIEF, CIVIL DESIGN SECTION B



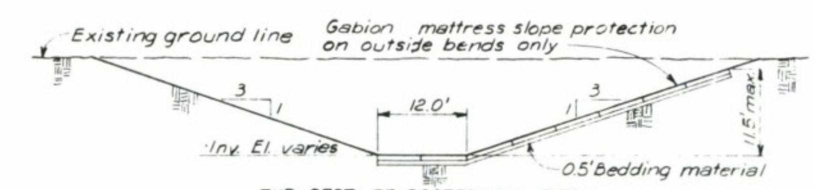
RESERVOIR MAP
NOT TO SCALE



TYP. SECT - REDBANK CREEK SOIL CEMENT EMBANKMENT
NOT TO SCALE



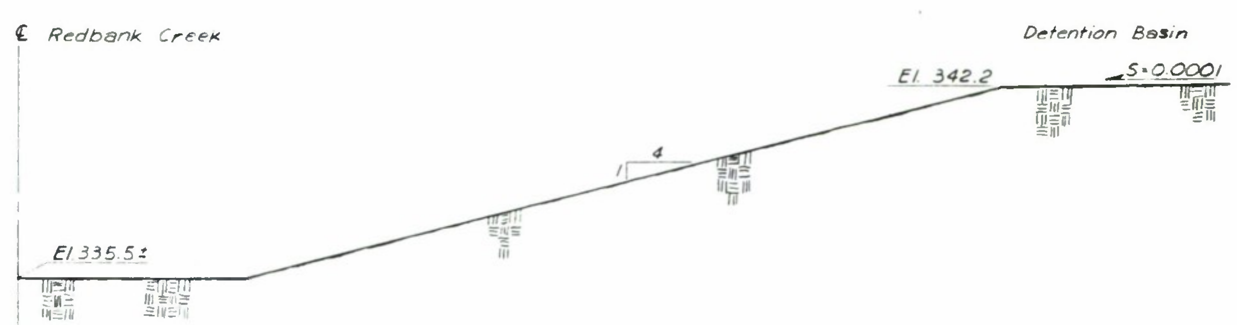
TYP. SECT - BASIN SOIL CEMENT EMBANKMENT
NOT TO SCALE



TYP. SECT - RELOCATED MILL DITCH
SCALE 1" = 10'

NOTE
1. Elevations are in feet and refer to the National Geodetic Vertical Datum of 1929.

GRAPHIC SCALE
1" = 10' 0 5 10' 20' 30' 40' 50'



SECTION A-A TYPICAL BASIN INLET SLOPE
NOT TO SCALE

REVISION	DATE	DESCRIPTION	BY	BY

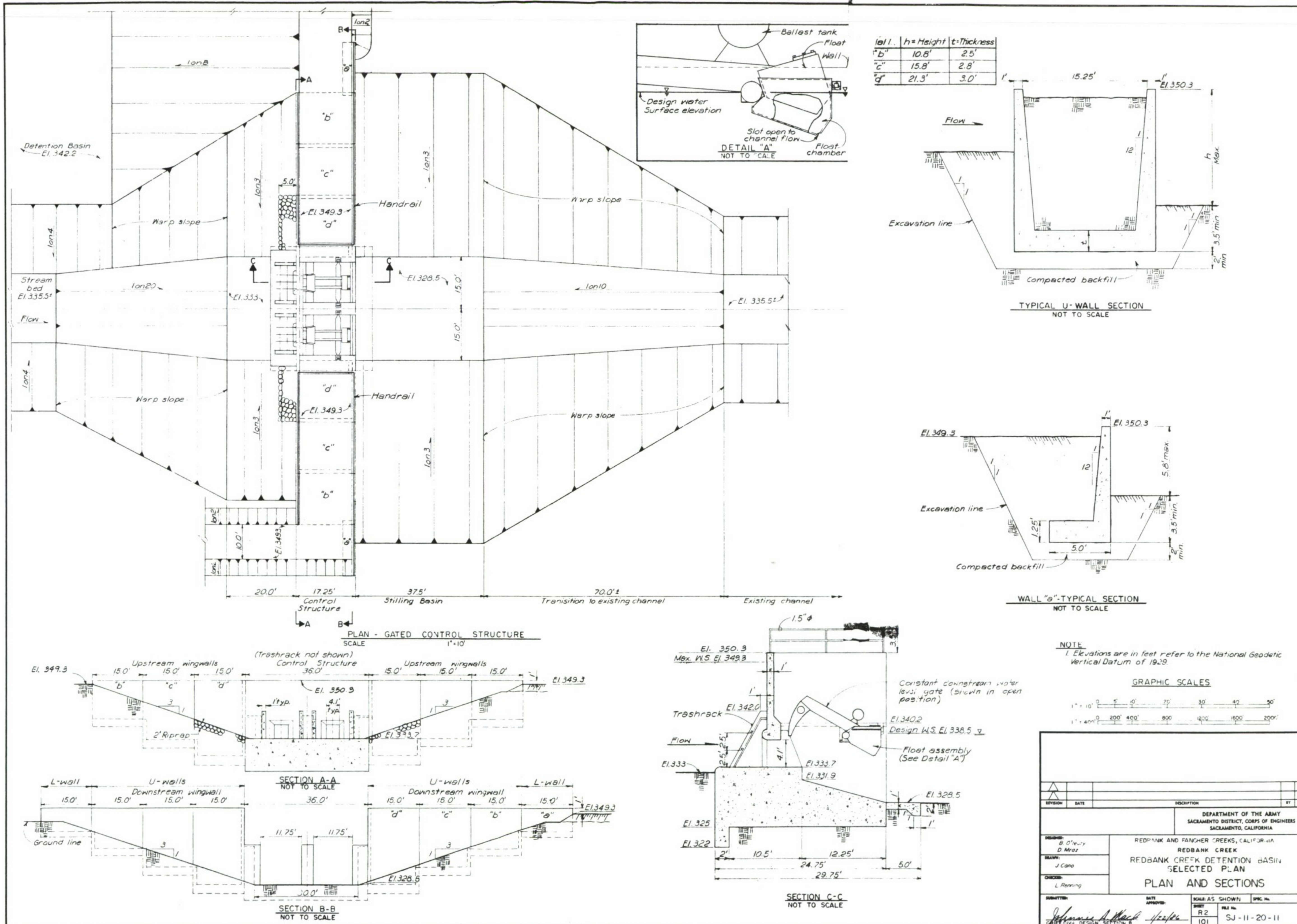
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

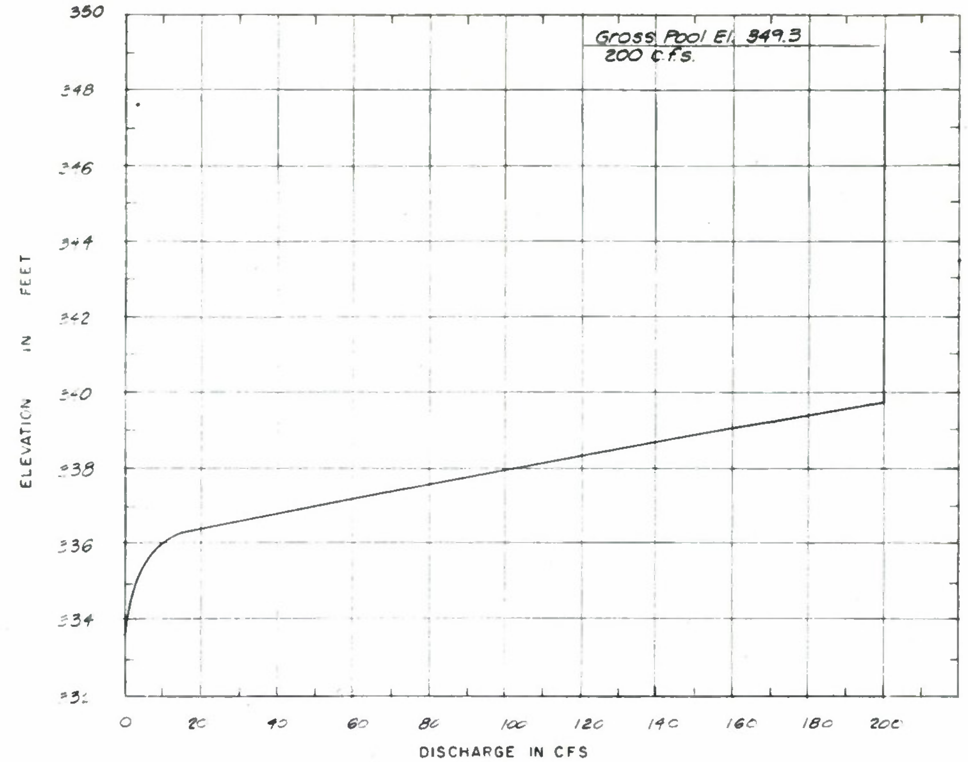
DESIGNED B. O'Leary, D. Mroz
DRAWN J. Cano
CHECKED L. Renning

REDBANK AND FANCHER CREEKS, CALIFORNIA
REDBANK CREEK
REDBANK CREEK DETENTION BASIN
SELECTED PLAN
PLAN AND SECTIONS

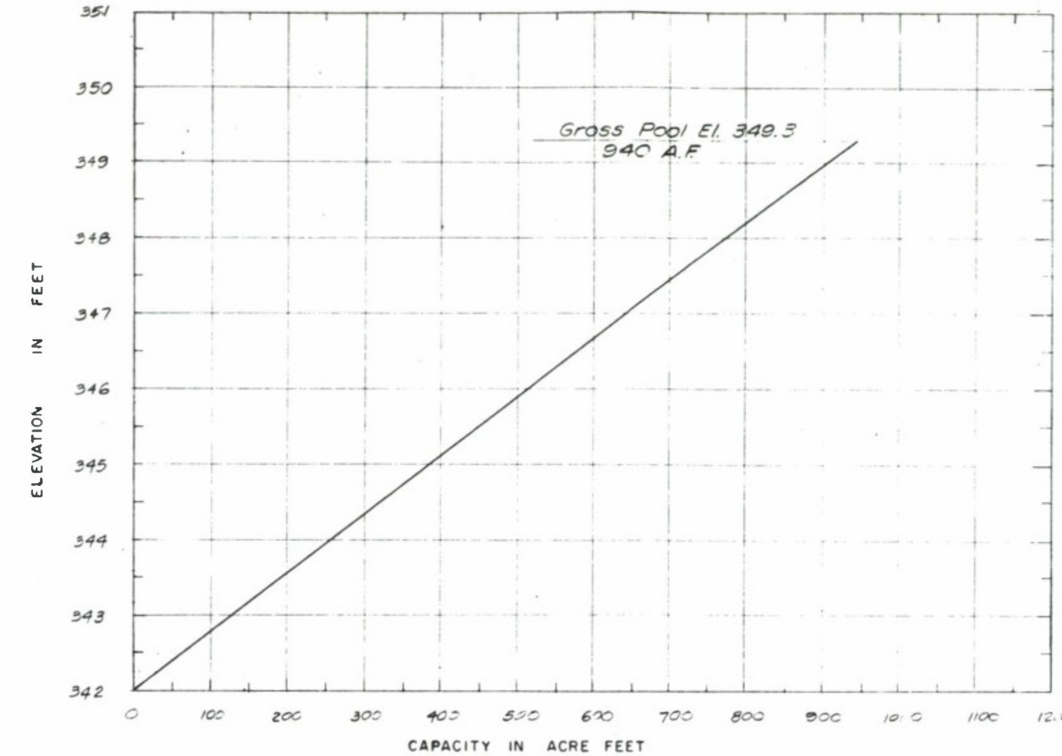
SUBMITTED Johannes A. Mack
CHIEF, CIVIL DESIGN, SECTION B
DATE APPROVED 4/22/86
SCALE AS SHOWN
SHEET R1 100
FILE No. SJ-11-20-11

SAFETY PAYS

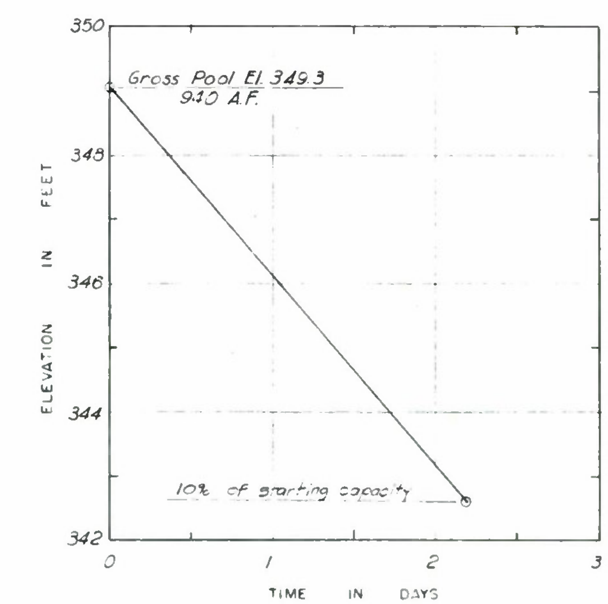

PLAN - GATED CONTROL STRUCTURE
SCALE 1"=10'
Detention Basin El. 342.2
Stream bed El. 335.5±
Flow
Warp slope
Handrail
El. 349.3
El. 333
El. 328.5
El. 335.5±
20.0'
17.25' Control Structure
37.5' Stilling Basin
70.0'± Transition to existing channel
Existing channel
DETAIL "A" NOT TO SCALE
Ballast tank
Float
Wall
Design water Surface elevation
Slot open to channel flow
Float chamber
Wall | h=Height | t=Thickness
"b" | 10.8' | 2.5'
"c" | 15.8' | 2.8'
"d" | 21.3' | 3.0'
TYPICAL U-WALL SECTION NOT TO SCALE
El. 350.3
15.25'
Excavation line
Compacted backfill
3.5' min
2' min
WALL "a"-TYPICAL SECTION NOT TO SCALE
El. 349.3
5.8' max.
5.0'
1.25'
SECTION A-A NOT TO SCALE
(Trashrack not shown)
Control Structure 36.0'
Upstream wingwalls
El. 350.3
2' Riprap
El. 343.7
SECTION B-B NOT TO SCALE
L-wall
U-walls Downstream wingwall
Ground line
11.75'
30.0'
El. 328.5
SECTION C-C NOT TO SCALE
1.5" ø
El. 350.3
Max. W.S. El. 349.3
Trashrack
El. 342.0
Constant downstream water level gate (shown in open position)
El. 340.2
Design W.S. El. 338.5
Float assembly (See Detail "A")
El. 333.7
El. 331.9
El. 325
El. 322
10.5'
12.25'
24.75'
29.75'
5.0'
NOTE
1. Elevations are in feet refer to the National Geodetic Vertical Datum of 1929.
GRAPHIC SCALES
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
REDBANK AND FANCHER CREEKS, CALIFORNIA
REDBANK CREEK
REDBANK CREEK DETENTION BASIN
SELECTED PLAN
PLAN AND SECTIONS
DESIGNED: B. O'Leary D. Mraz
DRAWN: J. Cano
CHECKED: L. Renning
SCALE: AS SHOWN
R2
101
SJ-11-20-11



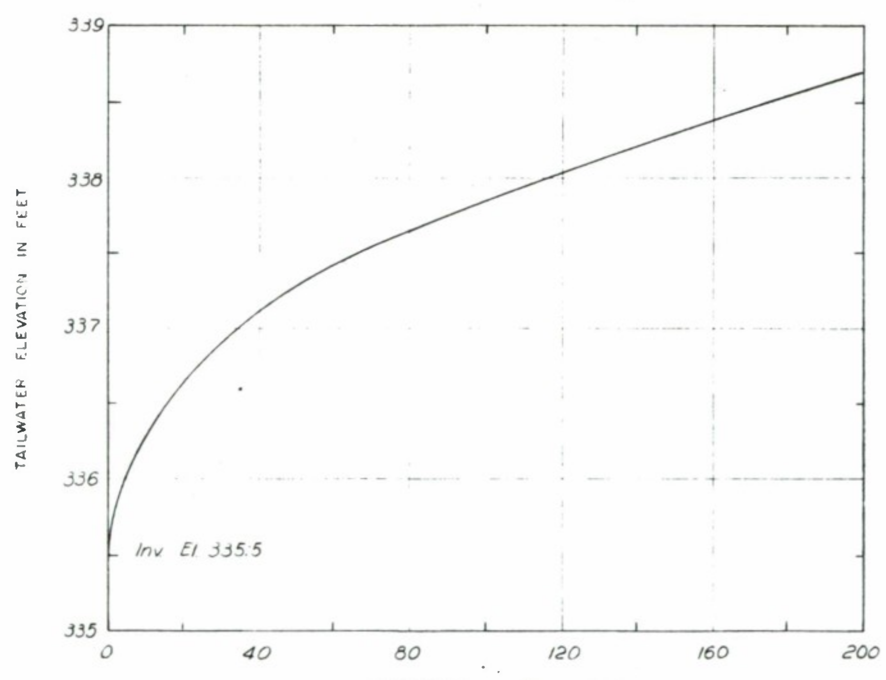
OUTLET WORKS RATING CURVE



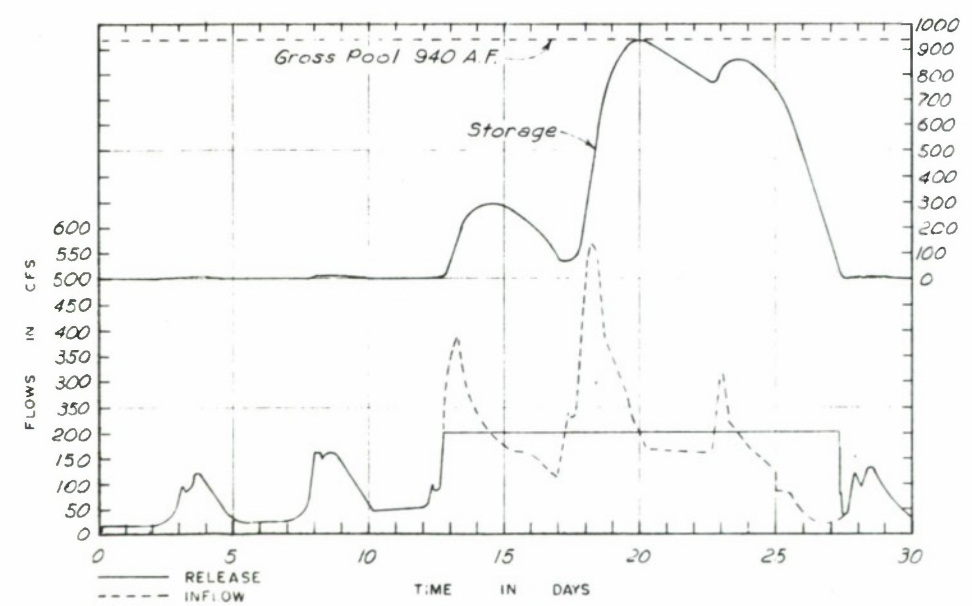
CAPACITY CURVE



DETENTION BASIN DRAWDOWN CURVE



OUTLET WORKS TAILWATER RATING CURVE



BASIN DESIGN FLOOD (200 YEAR) ROUTING CURVE

REVISION	DATE	DESCRIPTION	BY	BY

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DESIGNED: B. O'Leary
DRAWN: G. Buckwell
CHECKED: C. Milkovic
SUBMITTED: Harold C. Huff, CHIEF, HYDRAULIC DESIGN SECTION

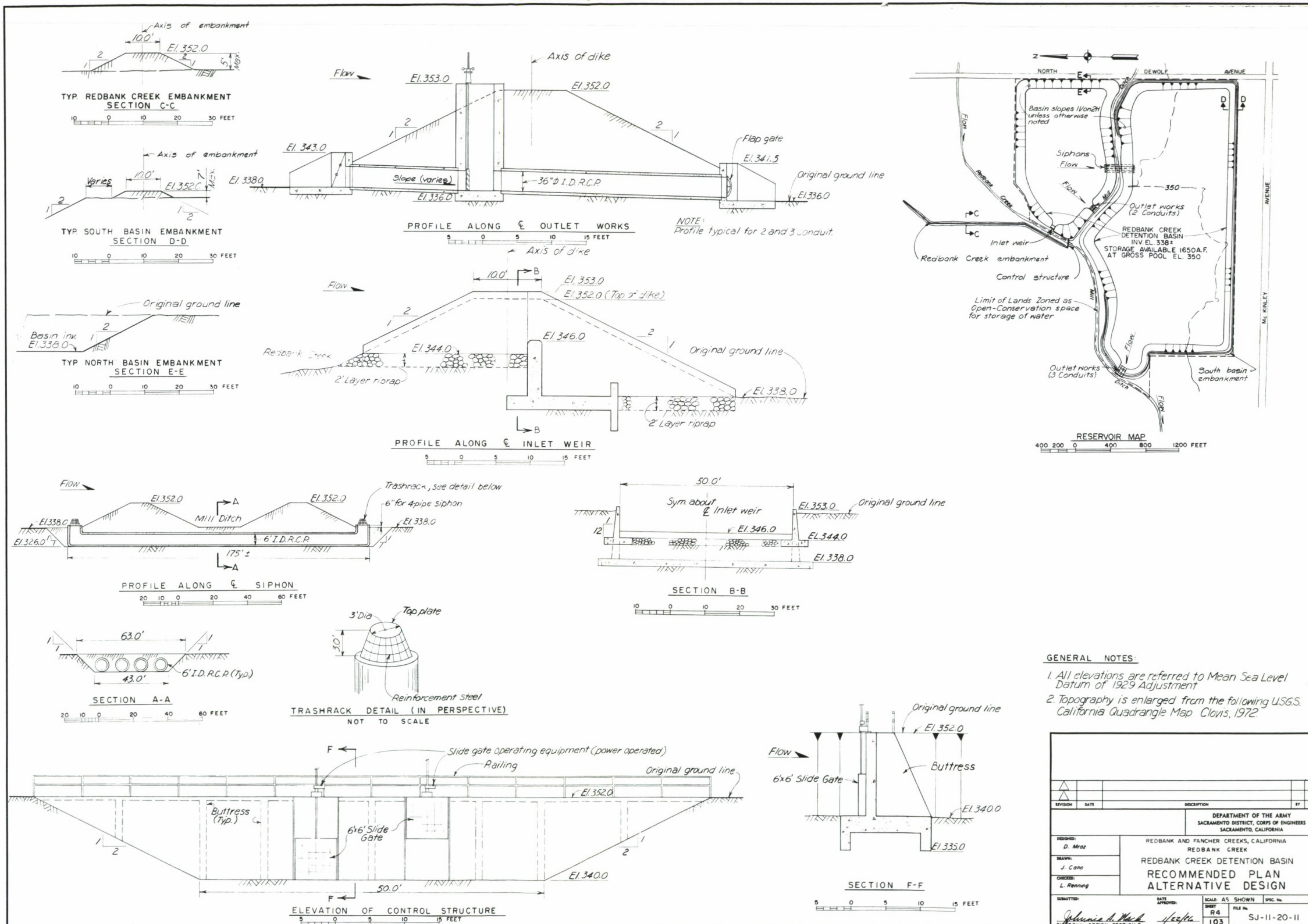
REDBANK AND FANCHER CREEKS CALIFORNIA

REDBANK CREEK DETENTION BASIN

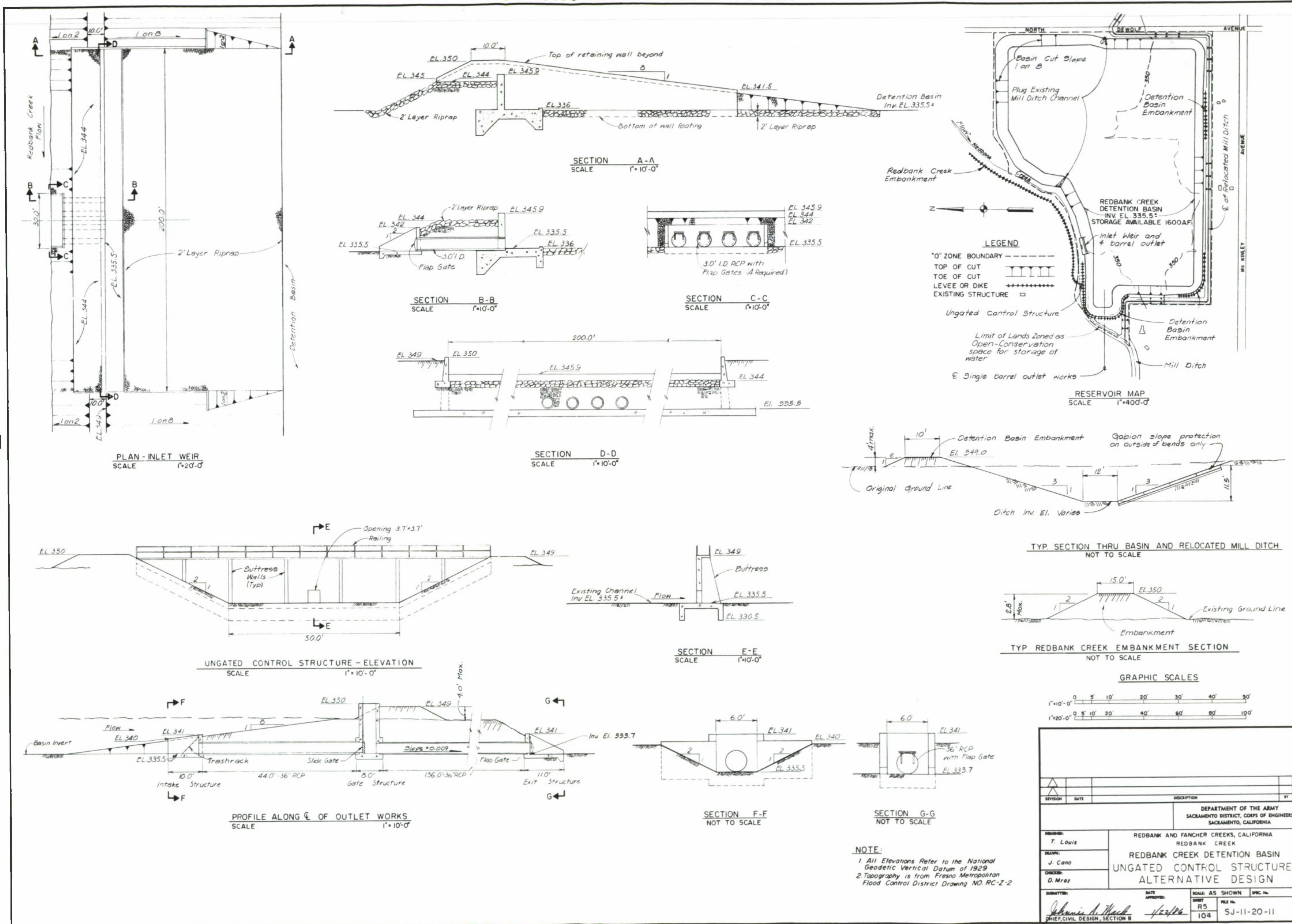
HYDRAULIC DATA

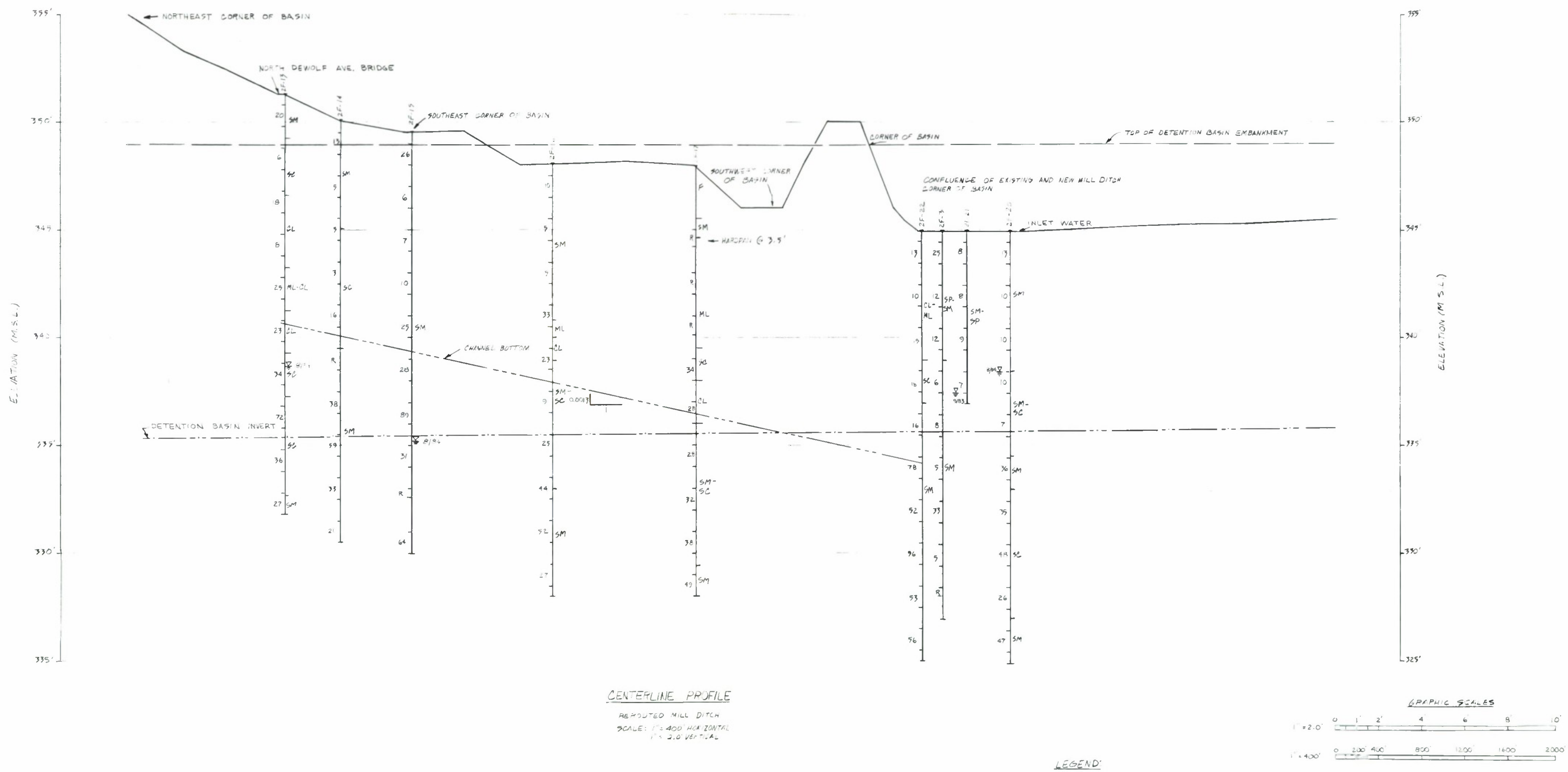
DATE APPROVED: 22 JAN 86
SCALE: AS SHOWN
SHEET: R3 102
FILE No.: SJ-11-20-11

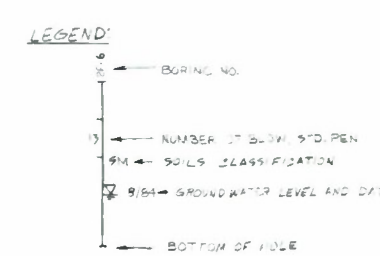
SAFETY PAYS



ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING


PLAN - INLET WEIR
SCALE 1"=20'-0"
Redbank Creek Flow
2' Layer Riprap
Detention Basin
EL 344
EL 335.5
200.0'
30.0'
10.0'
1 on 8
1 on 2
SECTION A-A
SCALE 1"=10'-0"
Top of retaining wall beyond
Bottom of wall footing
2' Layer Riprap
EL 350
EL 345
EL 344
EL 345.9
EL 336
EL 341.5
Detention Basin Inv EL 335.5±
SECTION B-B
SCALE 1"=10'-0"
3.0' I.D.
Flap Gate
SECTION C-C
SCALE 1"=10'-0"
3.0' I.D. RCP with Flap Gates (4 Required)
SECTION D-D
SCALE 1"=10'-0"
UNGATED CONTROL STRUCTURE - ELEVATION
SCALE 1"=10'-0"
Opening 3.7'x3.7'
Railing
Buttress Walls (Typ)
50.0'
SECTION E-E
SCALE 1"=10'-0"
Existing Channel Inv EL 335.5±
Flow
Buttress
EL 349
EL 330.5
PROFILE ALONG ℄ OF OUTLET WORKS
SCALE 1"=10'-0"
Basin Invert
Trashrack
Slide Gate
Flap Gate
Slope=0.009
Inv. El. 333.7
4.0' Max.
10.0' Intake Structure
44.0'-36" RCP
8.0' Gate Structure
136.0'-36" RCP
11.0' Exit Structure
SECTION F-F
NOT TO SCALE
SECTION G-G
NOT TO SCALE
36" RCP with Flap Gate
EL 333.7
RESERVOIR MAP
SCALE 1"=400'-0"
NORTH
DEWOLF
AVENUE
MC KINLEY AVENUE
Basin Cut Slope 1 on 8
Plug Existing Mill Ditch Channel
Detention Basin Embankment
℄ of Relocated Mill Ditch
Redbank Creek Embankment
REDBANK CREEK DETENTION BASIN INV. EL. 335.5± STORAGE AVAILABLE 1600AF
Inlet Weir and 4 barrel outlet
Mill Ditch
LEGEND
"O" ZONE BOUNDARY
TOP OF CUT
TOE OF CUT
LEVEE OR DIKE
EXISTING STRUCTURE
Ungated Control Structure
Limit of Lands Zoned as Open-Conservation space for storage of water
℄ Single barrel outlet works
Detention Basin Embankment
Gabion slope protection on outside of bends only
El. 349.0
Original Ground Line
Ditch Inv. El. Varies
TYP. SECTION THRU BASIN AND RELOCATED MILL DITCH
NOT TO SCALE
Existing Ground Line
Embankment
TYP. REDBANK CREEK EMBANKMENT SECTION
NOT TO SCALE
GRAPHIC SCALES
NOTE:
1. All Elevations Refer to the National Geodetic Vertical Datum of 1929
2. Topography is from Fresno Metropolitan Flood Control District Drawing NO. RC-Z-2
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
REDBANK AND FANCHER CREEKS, CALIFORNIA
REDBANK CREEK
REDBANK CREEK DETENTION BASIN
UNGATED CONTROL STRUCTURE
ALTERNATIVE DESIGN
DESIGNED: T. Louis
DRAWN: J. Cano
CHECKED: D. Mraz
CHIEF, CIVIL DESIGN, SECTION B
4/22/86
SCALE: AS SHOWN
SHEET R5 104
SJ-11-20-11





REVISION	DATE	DESCRIPTION	BY	BY

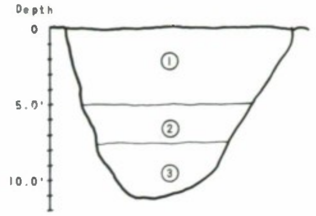
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DESIGNED: K. Swanson
DRAWN: K. Wohl
CHECKED: D. Anderson
SUBMITTED: CHEIF, SOILS DESIGN SECTION

REDBANK AND FANCHER CREEKS, CALIFORNIA
MILL DITCH
REDBANK CREEK DETENTION BASIN
SOIL PROFILE
REROUTED MILL DITCH

DATE APPROVED:
SCALE:
SHEET R6 / 105
FILE No. SJ-11-20-11
SPEC. No.

4B-20



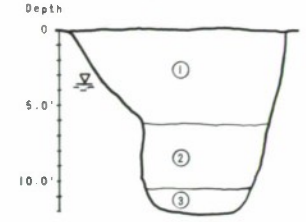
(1) SILTY SAND (SM), reddish-brown, 13% moisture content, 71% very fine to medium grained sand, 29% non- to low plasticity fines, loose to firm, non-cemented

Becomes saturated at lower portion of unit near contact with underlying hardpan

(2) SILTY SAND (SM), brick red, damp to moist, est. 70-80% very fine to fine grained sand, est. 20-30% low plasticity fines, very firm to stiff, poorly to moderately cemented (F.C.)

(3) SILTY SAND (SM), reddish-brown to brown, damp to moist, 69% very fine to medium subangular to subrounded grained sand, 31% low plasticity fines (LL = 20, PI = 3), very firm to dense, moderately cemented

4B-21



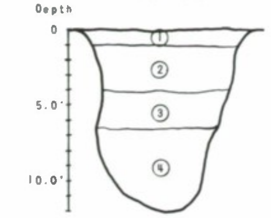
Aug 1983

(1) *CLAYEY SAND (SC), reddish-brown, moist, est. 75% graded subangular to subrounded grained sand, est. 25% medium plasticity fines, soft to firm, non-cemented

(2) SILTY SAND (SM), medium brown, 10% moisture content, 71% very fine to medium grained sand, 29% low plasticity fines, loose to firm, well cemented (hardpan)

(3) *SILTY SAND (SM), yellowish-brown, damp, est. 55% graded sand, est. 45% low plasticity fines, traces of fine gravel, loose to firm, well cemented but decomposed

4B-22



(1) SILTY SAND (SM), pale yellowish-brown to greyish-orange, est. 70-80% very fine to fine grained sand, est. 20-30% low plasticity fines, top soil (F.C.)

(2) SILTY SAND (SM), medium brown, 7% moisture content, 76% very fine to medium grained sand, 24% low plasticity fines (LL = 14, PI = 1), loose to firm, non-cemented

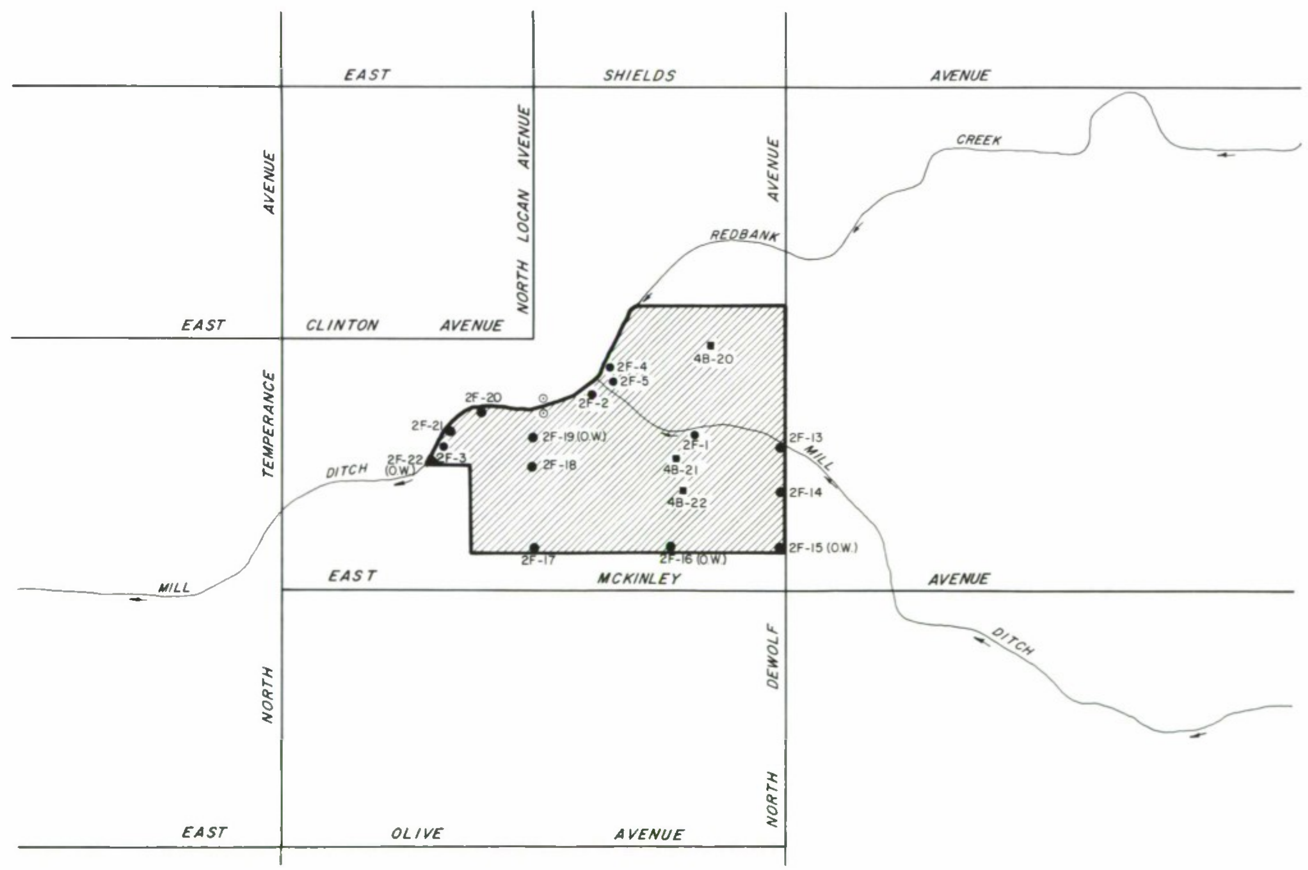
(3) CLAYEY SAND (SC), medium to light brown, damp to moist, 50% very fine to medium grained sand, 50% low plasticity fines (LL = 24, PI = 9), firm becoming stiff with depth, slightly cemented, scattered carbonaceous material

(4) SANDY SILT (ML), mottled light to pale yellowish-brown, damp to moist, est. 60-70% low to medium plasticity fines, est. 30-40% very fine grained sand, soft to firm, non-cemented, micaceous (F.C.)

Scale: 1" = 5'

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			GROUP SYMBOLS	TYPICAL NAMES
COARSE GRAINED SOILS 50% or more retained on the No. 200 sieve.	GRAVELS More than half of coarse fraction retained on the No. 4 sieve.	Clean gravels	GW	Well-graded gravels, gravel-sand mixtures, little or no fines.
			GP	Poorly-graded gravels, gravel-sand mixtures, little or no fines.
		Gravels with fines	GM	Silty gravels, gravel-sand mixtures.
			GC	Clayey gravels, gravel-sand-clay mixtures.
	SANDS More than half of coarse fraction passing the No. 4 sieve.	Clean sands	SW	Well-graded sands, gravelly sands, little or no fines.
			SP	Poorly-graded sands, gravelly sands, little or no fines.
		Sands with fines	SM	Silty sands, sand-silt mixtures.
			SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS More than 50% passing the No. 200 sieve.	SILTS AND CLAYS	Liquid Limit below 50%	ML	Inorganic silts and very fine sands, rock flour, silty fine sands or silts. Plasticity below "A" line.
			CL	Inorganic clays, gravelly clays, sandy clays, lean clays. Plasticity above "A" line.
			OL	Organic silts and organic clays. Plasticity below "A" line.
		Liquid Limit 50% and above	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts. Plasticity below "A" line.
			CH	Inorganic fat clays. Plasticity above "A" line.
			OH	Organic clays or organic silts. Plasticity below "A" line.
Highly organic soils			Pt	Peat, organic content greater than 60%.



LOCATION MAP

SCALE 1" = 800'

LEGEND:

● ■ Location of Exploration.

GR Gravel, percent by weight passing 3-inch sieve and retained on the No. 4 sieve.

SA Sands, percent by weight passing the No. 4 sieve and retained on the No. 200 sieve.

FI Fines, percent by weight passing the No. 200 sieve.

LL Liquid Limit.

PI Plasticity Index (Liquid Limit Minus Plastic Limit).

MC Field Moisture Content in Percent of Dry Weight.

(F.C.) Visual Field Classification.

* Laboratory Visual Classification.

▽ Groundwater Level.

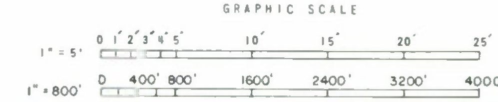
⊙ Proposed Future Explorations

OW Observation Well.

NOTES:

1. Classifications are in accordance with the Unified Soils Classification System (ASTM D-2487).
2. All sieve sizes on the chart are U.S. Standard.
3. The terms "silt" and "clay" are used respectively to distinguish materials exhibiting lower plasticity from those with higher plasticity. The minus No. 200 sieve material is silt if the liquid limit and plasticity index plot below the "A" line on the plasticity chart (ASTM D-2487) and is clay if the liquid limit and plasticity index plot above the "A" line on the chart.
4. Borderline Classification: Soils possessing characteristics of two groups are designated by combinations of group symbols. For example GW-GC, a well-graded gravel-sand mixture with a clay binder.
5. Trenches 4B-20 through 4B-22 were dug with a Case 580C backhoe during 10-12 August 1983.
6. For additional logs of explorations in the Redbank Detention Basin area, see sheet No. R7 R10
7. Groundwater was encountered during trenching.

GRAPHIC SCALE



REVISION	DATE	DESCRIPTION	BY	BY
△				
△				

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DESIGNED: K. SWANSON
DRAWN: K. WAHL/J. HAYES
CHECKED: D. ANDERSON

REDBANK AND FANCHER CREEKS, CALIFORNIA
REDBANK CREEK

REDBANK CREEK DETENTION BASIN
LOGS OF EXPLORATIONS
4B-20 thru 4B-22

SUBMITTED: [signature] CHIEF, SOILS DESIGN SECTION
DATE APPROVED: 4/24/86
SCALE:
SPEC. No.
SHEET R7 106
FILE No. SJ-11-20-11

2F-1

Depth	Symbol	N	GR	SA	FI	LL	PI	MC	Description
0	SM	17	-	-	-	-	-	-	*SILTY SAND, yellowish-brown, damp, est. 75% fine grained sand, est. 25% low plasticity fines, non-cemented
2.5'		R							SILTY SAND, light brown, very fine to coarse grained sand, non- to slightly cemented
		R	-	73	27	22	4	11	
6.5'		R							*SILTY SAND, dark brown, damp, est. 60% coarse grained sand, est. 40% low plasticity fines, slightly cemented
8.0'			-	66	34	22	3	-	SILTY SAND, greyish-orange to dark yellowish-brown, dry, very fine to medium grained sand, slightly cemented
		R							
10.0'	SC	30							*CLAYEY SAND, dark brown, moist, est. 75% graded sand, est. 25% medium plasticity fines, non-cemented
		41	-	-	-	-	-	-	
		44							
		36							
17.3'	SM		-	72	26	-	-	15	SILTY SAND, medium to light brown, very fine to medium grained sand, non-cemented
18.5'	SC	R	-	-	-	-	-	-	*SANDY CLAY, dark brown, damp, est. 75% medium plasticity fines, est. 25% graded sand, non-cemented
20.0'									

2F-2

Depth	Symbol	N	GR	SA	FI	LL	PI	MC	Description
0	SM		-	73	27	18	2	-	SILTY SAND, medium brown, damp, very fine to medium grained sand
5.0'	SM-SC		-	-	-	-	-	-	*SILTY SAND, yellowish-brown, moist, est. 85% graded sand, est. 15% low plasticity fines, trace of fine gravel
11.0'	SM	40	-	60	40	-	-	11	SILTY SAND, light brown, very fine to medium grained sand, non-cemented
12.5'	SM-SC	19	-	-	-	-	-	-	*SILTY SAND, yellowish-brown, moist, est. 85% graded sand, est. 15% low plasticity fines, traces of fine gravel
14.0'	SM	73	-	83	37	20	2	13	SILTY SAND, medium brown to medium yellowish-brown, very fine to medium grained sand, non-cemented
16.5'	SC	22	-	-	-	-	-	-	*CLAYEY SAND, dark brown, moist, est. 65% graded sand, est. 15% medium plasticity fines, traces of fine gravel
▽ 16.5'		30							
19.5'									

Aug 1983

2F-3

Depth	Symbol	N	GR	SA	FI	LL	PI	MC	Description
0	SP-SM	25							SILTY SAND, dark yellowish-brown, dry, very fine to medium grained sand, non- to low plasticity fines, non-cemented
		12	-	92	8	-	-	4	
		12							
6.0'	SM	8							*SILTY SAND, brown, moist, est. 65% graded sand, est. 15% non-plastic fines, traces of fine gravel
▽ 7.5'			-	-	-	-	-	-	
		8							
10.0'	SP	5							SAND, dark yellowish-brown, fine to coarse angular to subangular grained sand, non-cemented, micaceous, arkosic, G_s = 2.75
		33							
			3	93	4	-	-	-	
		5							
		R							Sloughing of side walls caused false blow count readings
16.0'									

Aug 1983

Vertical Scale: 1" = 2'

2F-4

Depth	Symbol	N	GR	SA	FI	LL	PI	MC	Description
0	SM	45							SILTY SAND, medium to light brown, dry to damp, very fine to medium grained sand, non-cemented
		61	-	76	24	-	NP	-	
5.5'	SP-SM	39							SILTY SAND, medium brown, very fine to medium grained sand, non-cemented
		6							
		12	-	91	9	-	-	7	
		6							
12.5'	SC	3							*CLAYEY SAND, brown, wet, est. 60-70% graded sand, est. 30-40% medium plasticity fines
▽ 13.5'		6	-	-	-	-	-	-	
		5							
19.1'	(SM)	6	-	-	-	-	-	-	SILTY SAND, medium to dark yellowish-brown, moist, est. 60% very fine to medium grained sand, est. 40% medium plasticity fines, non-cemented
19.5'									

Aug 1983

2F-5

Depth	Symbol	N	GR	SA	FI	LL	PI	MC	Description
0	SM	17							*SILTY SAND, reddish-brown, damp, est. 85% graded sand, est. 15% low plasticity fines, traces of fine gravel, non-cemented
		5	-	-	-	-	-	-	
		2							
6.0'	SM-SC	15	-	77	23	22	4	6	SILTY CLAYEY SAND, medium to light brown, very fine to medium grained sand, non-cemented, G_s = 2.76
6.5'	SP-SM	11	-	-	-	-	-	-	*SILTY SAND, dark brown, moist, est. 90% graded sand, est. 10% non-plastic fines, traces of fine gravel, non-cemented
		22							
11.5'	SM-SC	44	-	67	33	23	5	-	SILTY CLAYEY SAND, medium yellowish-brown, damp, very fine to medium grained sand, non-cemented
14.0'	SC	11	-	-	-	-	-	-	*CLAYEY SAND, brown, moist, est. 60% graded sand, est. 20% medium plasticity fines
		12							
18.5'	ML	50	-	46	54	38	10	21	SANDY SILT, medium to dark yellowish-brown, very fine to medium grained sand, non-cemented
19.5'									

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			GROUP SYMBOLS	TYPICAL NAMES
COARSE GRAINED SOILS 50% or more retained on the No. 200 sieve.	GRAVELS More than half of coarse fraction retained on the No. 4 sieve.	Clean Gravels	GW	Well-graded gravels, gravel-sand mixtures, little or no fines.
			GP	Poorly-graded gravels, gravel-sand mixtures, little or no fines.
		Gravels with fines	GM	Silty gravels, gravel-sand mixtures.
			GC	Clayey gravels, gravel-sand-clay mixtures.
	SANDS More than half of coarse fraction passing the No. 4 sieve.	Clean sands	SW	Well-graded sands, gravelly sands, little or no fines.
			SP	Poorly-graded sands, gravelly sands, little or no fines.
		Sands with fines	SM	Silty sands, sand-silt mixtures.
			SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS More than 50% passing the No. 200 sieve.	SILTS AND CLAYS	Liquid Limit below 50%	ML	Inorganic silts and very fine sands, rock flour, silty fine sands or silts. Plasticity below "A" line.
			CL	Inorganic clays, gravelly clays, sandy clays, lean clays. Plasticity above "A" line.
			OL	Organic silts and organic clays. Plasticity below "A" line.
		Liquid Limit 50% and above	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts. Plasticity below "A" line.
			CH	Inorganic fat clays. Plasticity above "A" line.
			OH	Organic clays or organic silts. Plasticity below "A" line.
Highly organic soils			Pt	Peat, organic content greater than 60%.

STANDARD PENETROMETER DESCRIPTIVE DATA

COHESIONLESS		COHESIVE	
Blows*	Relative Density	Blows*	Consistency
0-4	Very Loose	0-1	Very Soft
5-10	Loose	2-4	Soft
11-20	Firm	5-8	Firm
21-30	Very Firm	9-15	Stiff
31-50	Dense	16-30	Very Stiff
51+	Very Dense	31+	Hard

*Blows per 1.0 ft. of penetration of a 2-inch O.D. and 1⅜-inch I.D. sampler driven by a 140-lb. hammer, 30-inch freefall.

LEGEND:

- G_s Specific Gravity. (Minus No. 4)
- GR Gravel, percent by weight passing 3-inch sieve and retained on the No. 4 sieve.
- SA Sands, percent by weight passing the No. 4 sieve and retained on the No. 200 sieve.
- FI Fines, percent by weight passing the No. 200 sieve.
- LL Liquid Limit.
- PI Plasticity Index (Liquid Limit Minus Plastic Limit).
- MC Field Moisture Content in Percent of Dry Weight.
- OW Observation Well.
- • Laboratory Visual Classification.
- N Number of Blows of Standard Penetrometer.
- R Refusal with Standard Penetrometer.
- A Attempt with Standard Penetrometer.
- ▽ Groundwater Level.

NOTES:

1. Classifications are in accordance with the Unified Soils Classification System (ASTM D-2487).
2. All sieve sizes on the chart are U.S. Standard.
3. The terms "silt" and "clay" are used respectively to distinguish materials exhibiting lower plasticity from those with higher plasticity. The minus No. 200 sieve material is silt if the liquid limit and plasticity index plot below the "A" line on the plasticity chart (ASTM D-2487) and is clay if the liquid limit and plasticity index plot above the "A" line on the chart.
4. Borderline Classification: Soils possessing characteristics of two groups are designated by combinations of group symbols. For example GW-GC, a well-graded gravel-sand mixture with a clay binder.
5. Borings 2F-1 through 2F-5 were drilled with a Mobile B-80 drill rig equipped with a 6-1/2-inch hollow stem auger on 30 and 31 August 1983.
6. For additional logs of explorations in the Redbank Creek Detention Basin area, see sheet No. R7-R10.
7. For location of explorations, see sheet No. R7.
8. Groundwater was encountered during drilling.

GRAPHIC SCALE

1" = 2' 0 1' 2' 4' 6' 8' 10'

NOTES (Continued):

9. Refusal of the Standard Penetrometer is defined as one of the following:
   a. 25 blows for 1" or less advancement of sampler; or
   b. 50 blows for 1" to 6" advancement of sampler.
10. Attempt with the Standard Penetrometer is defined as refusal within the first 6": seating penetration.
11. Borings 2F-13 thru 2F-22 were drilled with a 6-inch diameter hollow stem auger on 3 thru 8 August 1984.

REVISION	DATE	DESCRIPTION	BY
△			
△			

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DESIGNED: K. SWANSON
DRAWN: K. WAHL/J. HAYES
CHECKED: D ANDERSON
SUBMITTED: Clark E. Strange — CHIEF, SOILS DESIGN SECTION
DATE APPROVED: 4/22/86

REDBANK AND FANCHER CREEKS, CALIFORNIA
REDBANK CREEK

REDBANK CREEK DETENTION BASIN
LOGS OF EXPLORATIONS
2F-1 thru 2F-5

SHEET R8 / 107
FILE No. SJ-11-20-11

2F-13

DEPTH		N	GR	SA	FI	LL	PI	MC	Description
0 – 2.0'	(SM)	20	-	-	-	-	-	-	SILTY SAND, brown, dry to damp, est. 75-85% very fine grained sand, est. 15-25% low plasticity fines, non-cemented
2.0' – 4.7'	(SC)	6	-	-	-	-	-	-	CLAYEY SAND, brown to dark brown, damp to moist, est. 85-90% very fine grained sand, est. 10-15% fines, non-cemented
4.7' – 6.6'	(CL)	18	-	-	-	-	-	-	CLAY, light brown, dry to damp, est. 90-95% fines, est. 5-10% very fine grained sand, non-cemented, well compacted
6.6' – 6.0'	CL	8	-	40	60	28	10	16	SANDY CLAY, light brown with light tan stringers, very fine to medium grained sand, non-cemented
6.0' – 10.0'	ML-CL	25	-	41	59	23	6	-	SANDY CLAY, light brown, moist, very fine to medium grained sand, non-cemented
10.0' – 11.0'	CL		-	3	97	-	-	30	CLAY, tanish-grey, non-cemented, somewhat brittle
11.0' – ▽12.5' – 14.0'	(SC)	23, 34	-	-	-	-	-	-	CLAYEY SAND, orangish-brown, est. 75-65% very fine to fine grained sand, est. 15-25% fines, non-cemented
14.0' – 18.5'	SC	72, 36	-	70	30	27	7	16	CLAYEY SAND, reddish-brown, very fine to medium grained sand, non-cemented
18.5' – 19.5'	(SM)	27	-	-	-	-	-	-	SILTY SAND, reddish-brown to greyish-brown, moist, est. 70-80% very fine to fine grained sand, est. 20-30% low plasticity fines, non-cemented

3 August 1984

2F-14

DEPTH		N	GR	SA	FI	LL	PI	MC	Description
0 – 5.0'	SM	13, 5	-	82	18	-	NP	6	SILTY SAND, brown to dark brown, very fine to medium grained sand, non-cemented
5.0' – 8.8'	SC	5, 3	-	77	23	21	8	-	CLAYEY SAND, brown to dark brown, dry to damp, very fine to medium grained sand, non-cemented
8.8' – 10.5'	SC	16	12	66	20	28	9	11	CLAYEY SAND, reddish-brown, very fine to coarse angular to subangular grained sand, gravel to 3/4" size
10.5' – 14.0'	(SM)	R, 38	-	-	-	-	-	-	SILTY SAND, greyish-brown, damp, est. 80% very fine to medium grained sand, est. 20% medium plasticity fines, scattered cemented fragments.
14.0' – 16.0'	SM	59, 33	-	57	43	-	-	15	SILTY SAND, yellowish-brown, very fine to medium grained sand, non-cemented At 15.5' depth, stringers of reddish-brown clay
16.0' – 19.5'	(SM)	21	-	-	-	-	-	-	SILTY SAND, brown, damp to moist, est. 80-90% very fine to fine grained sand, est. 10-20% medium plasticity fines, non-cemented, micaceous

2F-15 (O. W.)

DEPTH		N	GR	SA	FI	LL	PI	MC	Description
0 – 1.5'	(SM)	26	-	-	-	-	-	-	SILTY SAND, brown, dry to damp, est. 65-75% very fine grained sand, est. 25-35% low plasticity fines, non-cemented
1.5' – 6.7'	SM	8, 7	-	76	24	-	NP	8	SILTY SAND, brown, very fine to medium grained sand, non-cemented
6.7' – 6.5'	SM	10	-	68	32	20	4	-	SILTY SAND, yellowish-brown, damp to moist, very fine to medium grained sand, non-cemented
6.5' – 11.0'	(SM)	25	-	-	-	-	-	-	SILTY SAND, light brown, moist, est. 80% very fine to fine grained sand, est. 40% low to medium plasticity fines, non-cemented
11.0' – 12.0'	SM	28	-	50	50	-	-	13	SILTY SAND, brownish-grey, very fine to medium grained sand, medium plasticity fines, non-cemented
12.0' – ▽14.3' – 16.6'	(SM)	89, 31	-	-	-	-	-	-	SILTY SAND, light brown, moist, est. 75-80% very fine to medium grained sand, est. 20-25% low to medium plasticity fines, non-cemented, well compacted
16.6' – 19.5'	(SM)	R, 64	-	-	-	-	-	-	SILTY SAND, orangish-brown, damp, est. 70-80% very fine to medium grained sand, est. 20-30% low plasticity fines, non-cemented, well compacted

6 August 1984

2F-16 (O. W.)

DEPTH		N	GR	SA	FI	LL	PI	MC	Description
0 – 4.0'	SM	10, 5	-	78	22	-	NP	6	SILTY SAND, dark brown, very fine to medium grained sand, non-cemented
4.0' – 7.2'	SM	5, 33	-	86	14	-	NP	-	SILTY SAND, brown, saturated, very fine to medium grained sand, non-cemented
7.2' – 6.0'	(ML)		-	-	-	-	-	-	SILT, yellowish-brown, damp, traces of fine grained sand, non-cemented
6.0' – 9.0'	SC		-	56	44	23	9	10	CLAYEY SAND, dark brown, very fine to medium grained sand, non-cemented
9.0' – 10.0'	(CL)	23	-	-	-	-	-	-	CLAY, mottled greenish-grey and reddish-brown, damp, traces of very fine grained sand
10.0' – 15.0'	SM-SC	9, 25	1	63	36	23	6	17	CLAYEY SAND, orangish-brown, very fine to medium grained sand, non-cemented
15.0' – 20.0'	(SM)	44, 52, 27	-	-	-	-	-	-	SILTY SAND, reddish-brown with streaks of black material, damp, est. 60-70% very fine to fine grained sand, est. 30-40% medium plasticity fines, non-cemented

2F-17

DEPTH		N	GR	SA	FI	LL	PI	MC	Description
0 – 2.5'	F		-	-	-	-	-	-	Not Sampled
2.5' – 3.3'	(SM)		-	-	-	-	-	-	SILTY SAND, brown with black stringers, damp, est. 80-85% very fine to fine grained sand, est. 15-20% medium plasticity fines, slightly cemented
3.3' – 8.5'	ML	R, R, R	-	42	58	31	5	14	SANDY SILT, brown, very fine to medium grained sand, moderately cemented, brittle SANDY SILT, brown, very fine to medium grained sand, moderately cemented, brittle
8.5' – 10.0'	SC	34	-	51	49	27	9	18	CLAYEY SAND, brown, very fine to medium grained sand, non-cemented
10.0' – 12.0'	CL	27	-	-	-	-	-	-	CLAY, mottled greenish-grey and reddish-brown, damp, scattered very fine grained sand, non-cemented
12.0' – 18.5'	SM-SC	36, 31, 38	1	67	22	22	5	12	CLAYEY SAND, orangish-brown, very fine to medium grained sand, non-cemented At 14.5' depth, very fine to coarse grained sand
18.5' – 20.0'	(SM)	49	-	-	-	-	-	-	SILTY SAND, orangish-brown, moist, est. 75-85% very fine grained sand, est. 15-25% low to medium plasticity fines, non-cemented

2F-18

DEPTH		N	GR	SA	FI	LL	PI	MC	Description
0 – 6.2'	SM	16, 7, 4	-	79	21	-	-	-	SILTY SAND, brown, dry to damp, very fine to medium grained sand, low plasticity fines, non-cemented
6.2' – 6.0'	(SM)	R	-	-	-	-	-	-	SILTY SAND, orangish-brown, dry, est. 60-70% very fine to fine grained sand, est. 30-40% low to medium plasticity fines, non-cemented, well compacted
6.0' – 12.0'	SM-SC	47, 32	1	64	35	20	4	11	SILTY SAND, orangish-brown, very fine to medium grained sand, gravel to 3/8" size, non-cemented
12.0' – ▽14.0' – 15.4'	SM	27, 28	-	-	-	-	-	-	SILTY SAND, greenish-brown, moist, est. 65-75% very fine to fine grained sand, est. 25-35% low plasticity fines, non-cemented At 15.2' depth, subangular gravel to 3/4" size
15.4' – 18.2'	ML	38	-	-	-	-	-	-	SANDY SILT, reddish-brown, damp, est. 65-75% low plasticity fines, est. 25-35% very fine grained sand, non-cemented
18.2' – 20.0'	ML	34	-	-	-	-	-	-	SANDY SILT, mottled greenish-brown and brown, moist, est. 70-80% low to medium plasticity fines, est. 20-30% very fine grained sand, non-cemented

7 August 1984

VERTICAL SCALE: 1" = 2'

2F-19 (O. W.)

DEPTH		N	GR	SA	FI	LL	PI	MC	Description
0 – ▽7.0' – 7.3'	SM	10, 5, 4, 30	-	61	19	-	NP	-	SILTY SAND, dark brown, damp, very fine to medium grained sand, non-cemented
7.3' – 8.0'	(SM)		-	-	-	-	-	-	SILTY SAND, orangish-brown, damp, est. 65-75% very fine grained sand, est. 25-35% low to medium plasticity fines, non-cemented
8.0' – 11.5'	ML	78, R	-	32	68	35	8	20	SANDY SILT, orangish-brown grading to brownish-grey, dry to damp, very fine to medium grained sand, slightly to moderately cemented, brittle At 10.0' depth, well cemented
11.5' – 14.0'	(SM)	23	-	-	-	-	-	-	SILTY SAND, light brown, damp to moist, est. 75-85% very fine grained sand, est. 15-25% low plasticity fines, non-cemented
14.0' – 16.0'	(ML)	70	-	-	-	-	-	-	SANDY SILT, grayish-brown, damp, est. 90% medium plasticity fines, est. 10% very fine grained sand, non-cemented
16.0' – 18.5'	(SM)	19	-	-	-	-	-	-	SILTY SAND, reddish-brown, damp, est. 80-90% very fine to medium with scattered coarse grained sand, est. 10-20% low plasticity fines, non-cemented
18.5' – 20.0'	(SM)	43	-	-	-	-	-	-	SILTY SAND, orangish-brown, damp, est. 70-80% very fine to fine grained sand, est. 20-30% medium plasticity fines, non-cemented

7 August 1964

NOTES:

1. For notes and legend, see Sheet No. R7
2. For additional logs of borings in the Redbank Detention Basin Site area, see Sheet No. R7-R10
3. For location of explorations, see Sheet No. R7

GRAPHIC SCALE

1" = 2'   0   1'   2'   4'   6'   8'   10'

REVISION	DATE	DESCRIPTION	BY	BY

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DESIGNED: K. Swanson
DRAWN: K. Wahl
CHECKED: D. Anderson

REDBANK AND FANCHER CREEKS, CALIFORNIA
REDBANK CREEK

REDBANK CREEK DETENTION BASIN LOGS OF EXPLORATIONS

2F-13 thru 2F-19

SUBMITTED: [signature]
CHIEF, SOILS DESIGN SECTION

DATE APPROVED: [date]

SCALE:
SPEC. No.
SHEET: R9 / 108
FILE No. SJ-11-20-11

ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING

2F-20

DEPTH		N	GR	SA	FI	LL	PI	MC	
0 – 6.5'	SM	13, 10, 10	1	67	32	-	NP	6	SILTY SAND, brown to dark brown, very fine to medium greinad sand, gravel to 1/2" siza, non-cemented
6.5' – 10.5'	SM-SC	10, 7	6	66	26	19	4	10	SILTY SAND, brown to dark brown, vary fine to coarsa greined send, grevel to 1/2" siza, non-camented. At 9.0' depth, scattered angular grevel to 3/4" size
10.5' – 12.0'	SM	36	-	-	-	-	-	-	SILTY SAND, brown to graylsh-brown, moist, est. 70-80% very fine to medium grained sand, est. 20-30% low to madium plasticity fines, non-cemanted
12.0' – 16.7'	SC	35, 36	-	74	26	27	9	12	CLAYEY SAND, orengish-brown with scattered streaks and patches of black materiel, very fine to medium greined send, non-camented
16.7' – 18.0'	(SC)	26	-	-	-	-	-	-	CLAYEY SAND, grayish-brown, demp, ast. 60% vary fine grained send, est. 40% fines, non-cemented
18.0' – 19.5'	(SM)	47	-	-	-	-	-	-	SILTY SAND, reddish-brown to greyish-brown, demp, est. 75-85% very fine to fina with scattered medium grained send, est. 15-25% medium plesticity fines, non-cemented

2F-21

DEPTH		N	GR	SA	FI	LL	PI	MC	
0 – 6.0'	SM-SP	8, 8, 9, 7	2	93	5	-	-	7	SILTY SAND, light colorad, vary fina to medium angular greined sand, non-cemented, erkosic

▽ 6.0' 8 August 1984 — Seepage from creek entering hole

VERTICAL SCALE: 1" = 2'

2F-22 (O.W.)

DEPTH		N	GR	SA	FI	LL	PI	MC	
0 – 6.0'	CL-ML	13, 10, 15	1	34	65	23	5	-	SANDY CLAY, brown, dry, very fine to madium grained send, greval to 1/2" siza, non-cemanted
6.0' – 8.5'	SC	18	1	69	30	24	10	6	CLAYEY SAND, brown, very fine to madium grained send, gravel to 3/8" siza, non-cemented
8.5' – 10.9'	SM	16	2	75	23	-	-	-	SILTY SAND, reddish-brown, dry to demp, very fine to medium anguler greined sand, gravel to 1/2" size, non-cementad
10.9' – 16.0'	SM	R, 52, 56	2	64	34	-	-	11	SILTY SAND, orangish-brown, very fina to medium grained sand, grevel to 1/2" size, non-cemented, brittle, well compectad
16.0' – 18.0'	(SM)	53							SILTY SAND, reddish-brown, demp, ast. 80-90% fina to coarse enguler greined send, est. 10-20% low plasticity fines, scattered enguler to subangular grevels to 5/8" size
18.0' – 20.0'	(SM)	52							SILTY SAND, orengish-brown, demp, est. 80-90% very fine to medium grained send, est. 10-20% low plasticity fines, non-cementad

NOTES:

1. For notes and lagand, sea Sheet No. R7.
2. For additionel logs of borings in the Redbenk Detention Basin Site aree, see Sheet No. R7-R9.
3. For locetion of exploretions, see Sheet No. R7.

GRAPHIC SCALE

1" = 2' — 0, 1', 2', 4', 6', 8', 10'

REVISION	DATE	DESCRIPTION	BY	BY

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

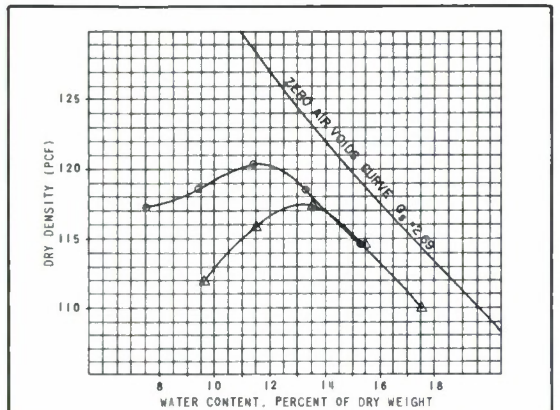
DESIGNED: K. Swanson
DRAWN: K. Wahl
CHECKED: D. Anderson

REDBANK AND FANCHER CREEKS, CALIFORNIA
REDBANK CREEK

REDBANK CREEK DETENTION BASIN
LOGS OF EXPLORATIONS
2F-20 thru 2F-22

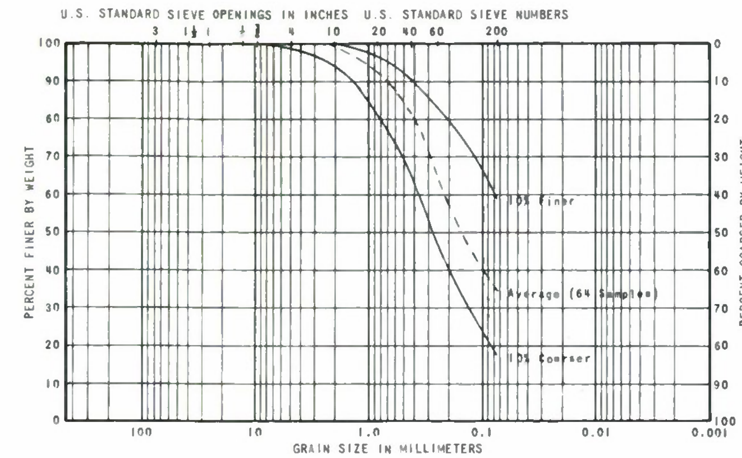
SUBMITTED: CHIEF, SOILS DESIGN SECTION
DATE APPROVED:
SCALE:
SPEC. No.
SHEET R10 / 109
FILE No. SJ-11-20-11

COMPACTION



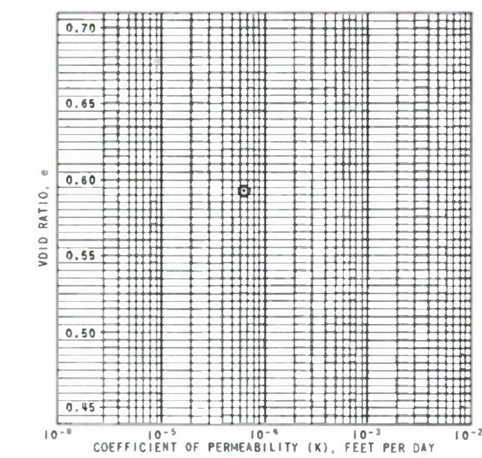
SYMBOL AND BORING NO.	MATERIAL	DEPTH (Feet)	SPECIFIC GRAVITY	ATTERBERG LIMITS LL	ATTERBERG LIMITS PI	SAMPLE CONTENT	OPTIMUM WATER CONTENT (%)	MAXIMUM DRY DENSITY (PCF)
○ 48-20	SILTY SAND (SM)	7.5-11.2	2.69	20	3	69% Sand, 31% Fines	11.7	120.5
△ 48-22	CLAYEY SAND (SC)	4.0-6.5	2.69	24	9	50% Sand, 50% Fines	13.7	117.4

GRADATION



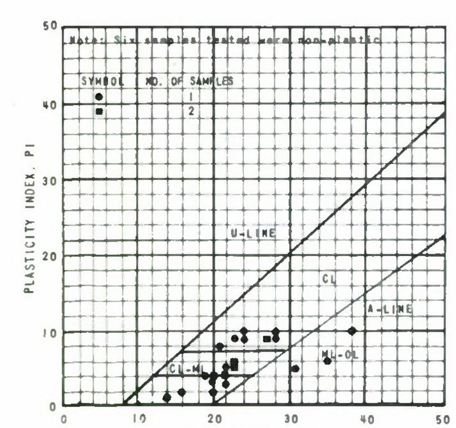
COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

PERMEABILITY



SYMBOL	MATERIAL	HOLE	DEPTH (Feet)	CONDITION
⊙	CLAYEY SAND (SC)	2F-4	12.5-19.5	Composite (Est. 60-70% Sand, Est. 30-40% Fines)

ATTERBERG LIMITS



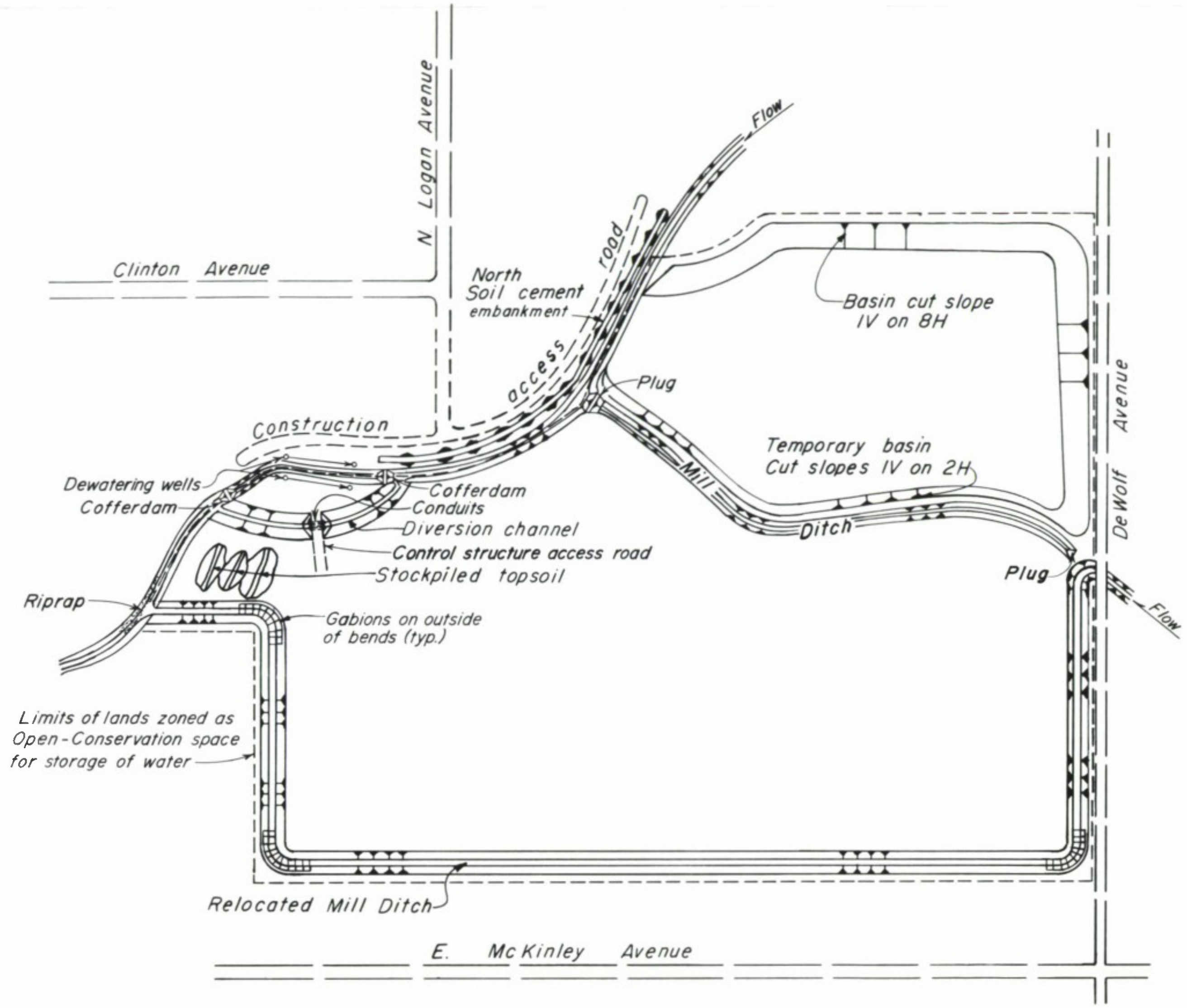
REVISION	DATE	DESCRIPTION	BY	BY
△				
△				

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

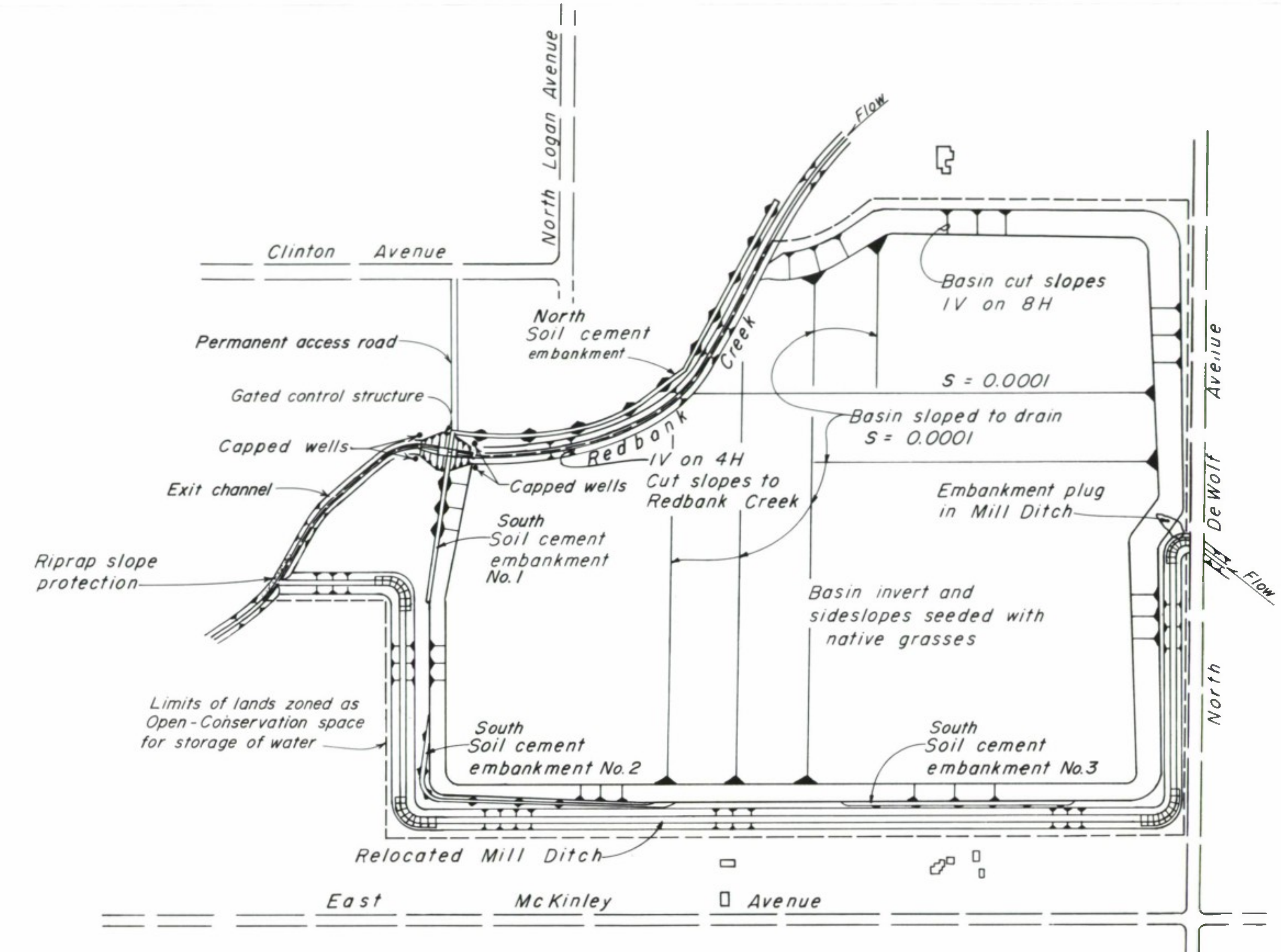
DESIGNED: K. Swanson
DRAWN: K. Wahl
CHECKED: D. Anderson

REDBANK AND FANCHER CREEKS, CALIFORNIA
REDBANK CREEK
REDBANK CREEK DETENTION BASIN
SUMMARY OF TEST RESULTS

SUBMITTED: CHIEF, SOILS DESIGN SECTION
DATE APPROVED:
SCALE:
SHEET R 11 / 110
FILE No. SJ-11-20-11
SPEC. No.



SECOND PROJECT CONSTRUCTION SEASON
NOT TO SCALE



THIRD PROJECT CONSTRUCTION SEASON
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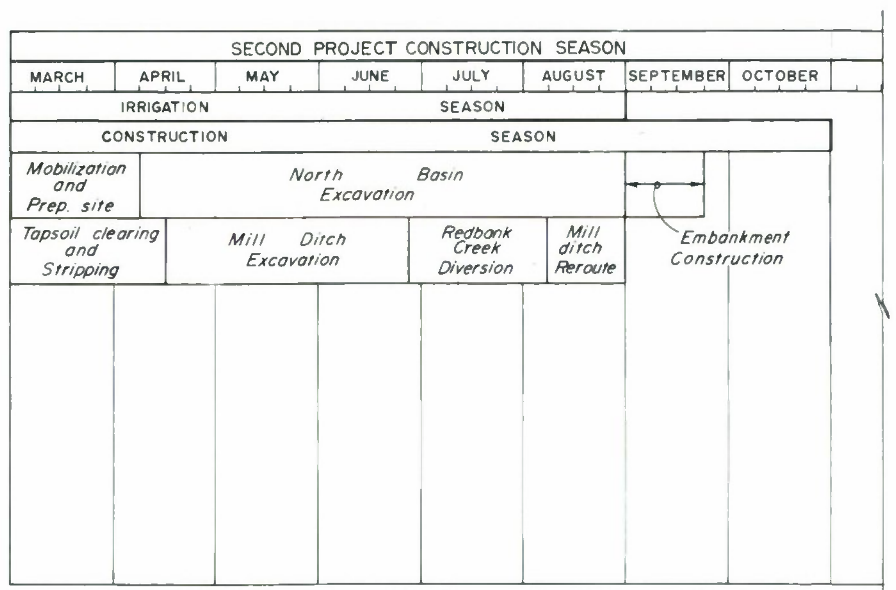

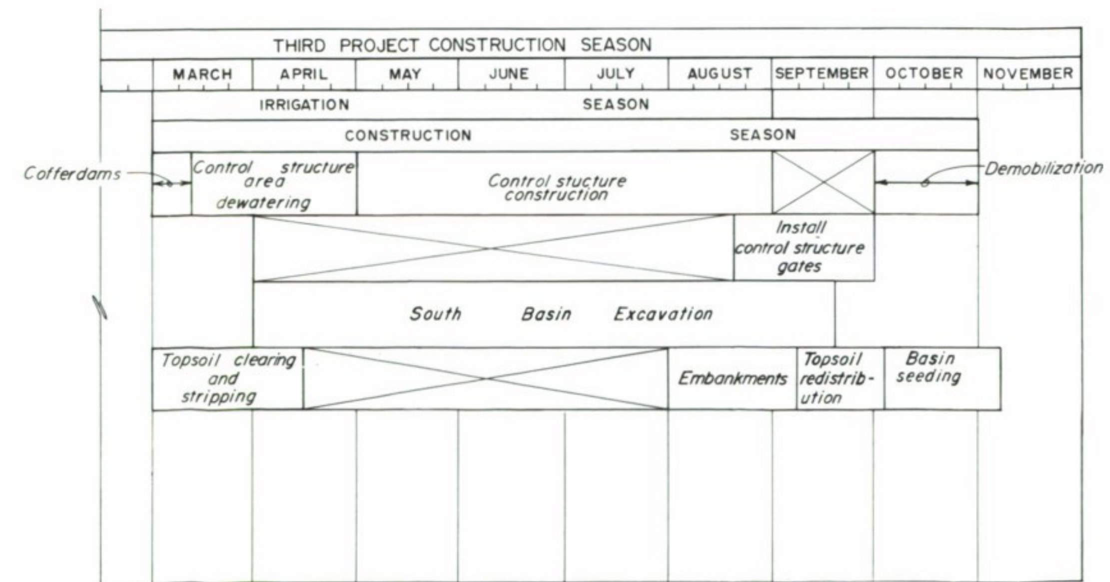

REVISION	DATE	DESCRIPTION	BY	BY

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DESIGNED: O Mroz
DRAWN: E. Clawson, J. Cono
CHECKED: L. Renning

REDBANK AND FANCHER CREEKS, CALIFORNIA
REDBANK CREEK
REDBANK CREEK DETENTION BASIN
CONSTRUCTION PLAN
AND SEQUENCE

SUBMITTED: [signature]
CHIEF, CIVIL DESIGN, SECTION B
DATE APPROVED: 1/22/86
SCALE: AS SHOWN
SPEC. No.
SHEET R 12 / 111
FILE No. SJ-11-20-11

REDBANK AND FANCHER CREEKS,
CALIFORNIA

APPENDIX A

HYDROLOGY

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT
SACRAMENTO, CALIFORNIA

APPENDIX A - HYDROLOGY

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Hydrology Appendix

1. Introduction. - The Redbank and Fancher Creek Feasibility Report was prepared and approved in 1979. On 7 April 1982, a General Design conference was held at Fresno, CA. At this conference, representatives from the Corps of Engineers, Washington Office (OCE), South Pacific Division (SPD), and Sacramento District Office (SPK) met to discuss the plan recommended in the Feasibility Report. Many issues were discussed: several dealt with hydrology. This appendix presents, in support of the Redbank and Fancher Creeks General Design Memorandum (GDM), the following:

a. A description of the project area and floods of record.

b. A discussion of the hydrologic methods and criteria used in computing the reservoir design floods, spillway design floods, sedimentation yield, and wind setup and wave runup, and flow-frequency curves.

c. A description of the HEC-1 basin model used to analyze the project features.

d. A discussion of the routing methods and parameters used to route the floods through the system.

e. A comparison of the Feasibility Report hydrology to the GDM hydrology.

2. Previous Hydrology. - Reports pertinent to study of the project area hydrology are as follows:

a. The revised definite project report, "Big Dry Creek Reservoir and Diversion," dated October 1945.

b. "Soil Survey, Eastern Fresno Area, U.S. Soil Conservation Service," October 1971.

c. "Redbank and Fancher Creeks Hydrology Report," USCE, Sacramento, California, June 1973.

d. "Big Dry Creek Reservoir and Diversion Hydrology Office Report," USCE, Sacramento, California, June 1973.

e. "Flood Hazard Analysis, Northeast Fresno, Fresno County, California," U.S. Soil Conservation Service, draft, June 1977.

f. "Fresno County Flood Insurance Study Hydrology," USCE, September 1978.

g. "Redbank and Fancher Creeks Feasibility Report for Water Resources Development," USCE, Sacramento, California, Feb 1979, Rev. 10 Sep 79.

h. "Big Dry Creek Dam and Diversion, Probable Maximum Flood Study," USCE, Sacramento, California, July 1980.

Studies c and d present the hydrology used for project formulation and appraisal in the Feasibility Report. The majority of the criteria and procedures used in these reports were used in the current hydrologic analysis. Studies b, e, and f, offer improved and updated hydrological data on soil types, loss rates, and channel routings. Study h provides the data and criteria for the Big Dry Creek Reservoir Spillway Design Flood.

3. Location and Nature of the Study Area. - The project area is the western slope of the Sierra Nevada foothills in eastern Fresno County, between the San Joaquin and Kings Rivers, Plate H1. The principal streams in the study area are Dry Creek (also known as Big Dry Creek), Dog Creek, Redbank Creek (also known as Redbank Slough) and Fancher Creek. Other local streams of concern are Alluvial Drain, Pup Creek and Mud Creek. Their flood plains extend from the foothills down to Fresno Slough and on to the San Joaquin River northwest of Fresno. These creeks flow in natural channels through the foothills and emerge onto the valley floor east of Fresno. Many of the natural channels on the valley floor have been extensively modified and, in effect, now are dual purpose; i.e., the channels are used for conveying both irrigation water and storm runoff. These dual purpose channels flow across agricultural land and through the Fresno-Clovis metropolitan area.

The major dual purpose canals are the Fresno Canal, Mill Ditch, Dry Creek Canal and the Herndon Canal. Other major canals in the area are the Friant-Kern Canal, Enterprise Canal, and Gould Canal. These canals cross the above mentioned creeks in the project area and serve to obstruct and change natural drainage patterns, Plate H1. Flood waters intercepted by the Enterprise and Gould Canals eventually enter the Herndon Canal. Any runoff entering the Friant-Kern Canal is transported out of the project area. The following paragraphs present a detailed description of each of the conveyance channels in the project area that are important to the proposed project. The capacities of these channels are shown in Table H-1.

a. Friant-Kern Canal. - The Friant-Kern Canal has a channel capacity of about 5,000 cfs and flows from northwest to southeast. It is the first major canal to modify the natural drainage pattern of Dry, Dog, Redbank, Fancher, and Mud Creeks. This canal only has a minor routing effect, since the majority of the flow originating above the canal either flows over or is siphoned under it. Flow from only a few small drainage areas enters or is stored behind the Friant-Kern Canal. These noncontributing drainage areas are shown on Plate H2, as shaded areas abutting the upstream canal levees.

b. Enterprise Canal. - The Enterprise Canal splits off of the Gould Canal just west of the Friant-Kern Canal and flows from southeast to northwest. This canal receives its irrigation water from the Kings River by way of the Gould Canal. The Enterprise Canal's bank full channel capacity through the project area varies from an estimated 350 cfs at the Gould-Enterprise Canal split to the 150 cfs siphon capacity under Dry Creek. Specifically, the Enterprise Canal capacity is estimated by the Fresno Irrigation District to be 350 cfs from the Gould Canal to the siphon under Redbank Creek. The siphon's capacity is 200 cfs. Excess flow spills over the canal bank and enters Redbank Creek below Redbank Creek Dam.

The Enterprise Canal channel capacity from the Redbank siphon northwest to Dry Creek is estimated at 200 cfs. The Enterprise siphon under Dry Creek can pass only 150 cfs. Any flows in excess of that spill into Dry Creek. Because of varying canal capacities, limited siphon capacities under and large ponding areas behind the unlined raised portions of the canal, there is potential for canal failure during large flood events.

c. Gould Canal. - The Gould Canal flows from the Kings River west until it joins the Dry Creek channel in Fresno. Because the Gould Canal banks are ground level it will intercept any overland flow up to channel capacity and carry it to Dry Creek. Any excess flow east of Redbank Creek will spill and continue southward until it enters the Fresno Canal. Any excess flow west of Redbank Creek and east of Dog Creek will eventually flow into Redbank Detention Basin. Any excess flow west of Dog Creek will continue overland until it is intercepted by Mill Ditch, and flow through Fresno to the Herndon Canal. The estimated bank full capacity from Mud Creek to just above Redbank Creek is 200 cfs. Gould Canal cuts through a lateral ridge to Redbank Creek. This causes an increase in capacity to about 300 cfs just upstream of the Redbank Creek siphon (maximum capacity is 150 cfs). Excess flow in the Gould Canal at the siphon will spill into Redbank Creek. The canal's capacity remains at 150 cfs to Dry Creek.

Under present operating conditions the Fresno Irrigation District can regulate the flow through the Enterprise siphon under Dry Creek and the Gould siphon under Redbank Creek. Normally the Gould Siphon is set at 90 cfs and the Enterprise siphon under Redbank Creek is normally set at 200 cfs during the flood season.

d. Fresno Canal. - The Fresno Canal runs along the southern boundary of the project area from the Kings River to the Mill Ditch-Fancher Creek split. The canal's capacity is estimated to be about 2,000 cfs. During large floods, the Fresno Canal will intercept all flows from Fancher Creek and all spills from the Gould Canal.

At the split, water is divided between Mill Ditch and Fancher Creek Canal. Fancher Creek Canal continues southwestward to the valley floor with a capacity of 500 cfs. Mill Ditch continues westward with a capacity of 900 cfs to the Herndon Canal, where the flow can be diverted to Dry Creek and the valley floor or north through the Herndon Canal (channel capacity is 500 cfs) to the San Joaquin River.

e. Redbank Creek. - Redbank Creek tributaries (that will not be diverted by the proposed Fancher Dam) flow under the Friant-Kern Canal into the reservoir. Releases from the Redbank Reservoir continue downstream over the Enterprise and Gould Canal siphons to Mill Ditch. The 1973 Redbank-Fancher Creek Hydrology Report presented a channel capacity of 300 cfs for Redbank Creek between Redbank Creek Reservoir and Mill Ditch. Channel encroachments have decreased the Redbank Creek channel capacity below the Enterprise Canal to approximately 90 cfs in the primary channel and 150 cfs in the secondary channel. Flows in excess of 300 cfs could cause some structural damage between the reservoir and the proposed Redbank Detention Basin.

f. Mud Creek. - Mud Creek flows under the Friant-Kern and Enterprise Canals and into the Gould Canal. During very rare events sufficient storage will build up behind the Enterprise Canal to force some of Mud Creek's flow to enter the Enterprise Canal. Mud Creek channel below the Enterprise Canal has been greatly modified. The creek channel is now routed around farmland and directly into the Gould Canal. Its channel capacity below the Enterprise Canal is only sufficient enough to handle local runoff and excess irrigation water.

g. Fancher Creek. - Fancher Creek flows through a chute over the Friant-Kern Canal, under the Enterprise Canal, over the Gould Canal and into the Fresno Canal.

In the 1973 Redbank-Fancher Creek Hydrology Report, a channel capacity of 600 cfs was presented for Fancher Creek between Friant-Kern Canal and Fresno Canal. Subsequent encroachments have decreased their channel capacities. Modifications to the Fancher Creek channel below the Enterprise Canal have decreased the carrying capacity to between 300 and 400 cfs.

h. Pup and Alluvial Creeks. - Pup Creek and Alluvial Drain are local drainages originating below the Friant-Kern Canal and Big Dry Creek Dam. Pup Creek flows under the Enterprise Canal and through Clovis to Dry Creek. Alluvial Drain, north of Pup Creek, flows under the Enterprise Canal to Marion and Alluvial Avenues, where it has to be pumped into Dry Creek.

i. Dog Creek. - Dog Creek runoff, originating below the Dog Creek Diversion, flows under the Friant-Kern, Enterprise and Gould canals and into Redbank Creek above Mill Ditch. Dog Creek above the diversion is diverted into Dry Creek, which flows over the Friant-Kern Canal siphon into Big Dry Creek Reservoir.

j. Dry Creek. - Most of Dry Creek's smaller tributaries above the Friant-Kern Canal flow under the Canal and into Big Dry Reservoir. The largest portion of the drainage area, 64.5 sq. mi. of the 81.7 sq. mi., are Dry and Dog Creeks, which are combined above the Friant-Kern Canal and flow across a chute over that canal. Dog Creek Diversion to Dry Creek has an outlet works to Dog Creek Big Dry Creek Dam has outlet works to Dry Creek and to Little Dry Creek diversion channel. During periods of high flow, the first two of these three gates are usually closed because of downstream requirements to evacuate local flow. The primary outlet for flood control is a gated outlet to the Little Dry Creek Diversion Channel. Releases to Little Dry Creek plus local flow intercepted by this diversion channel, must not exceed 700 cfs. This is done to prevent spills over the diversion's wasteway. Dry Creek below the Dam collects spills from the Enterprise Canal and water from Alluvial Drain, Pup Creek, local urban areas and the Gould Canal, before flowing into the Herndon Canal. Road bridges on Dry Creek above the Gould Canal have restricted the channel capacity to 150 cfs. Dry Creek channel capacity increases to 300 cfs at the Gould Canal and remains at that capacity until it reaches the Herndon Canal.

4. Existing, Authorized or Proposed Water Resource Development. - There are a number of existing flood control facilities in and around the Fresno-Clovis

Table H-1

1984 Channel Capacities

Channel 5/	Reach	Capacity
Fancher Creek	Friant-Kern Canal to Fresno Canal	300-400 1/
Fancher Creek	Mill Ditch to Manning Avenue	500
Redbank Creek	Dam to Mill Ditch	90-300 2/
Dry Creek	Dam to Herndon Canal	150
Dry Creek	Mill Ditch to Hwy. 99	350-425 3/
Dry Creek	Hwy. 99 to San Joaquin River	50-150 3/
Alluvial Drain	Enterprise Canal to Dry Creek (with pump)	25
Pup Creek	Temperance Avenue to Peach Avenue	40
Pup Creek	Villa Avenue to Dry Creek	25
Herndon Canal	Mill Ditch to San Joaquin River	500-550 3/
Little Dry Creek Diversion Channel	Big Dry Creek to Little Dry Creek	700
Enterprise Canal	Gould Canal to Redbank Creek	350 4/
Enterprise Siphon	Under Redbank Creek	200
Enterprise Canal	Redbank Siphon to Dry Creek	200
Enterprise Siphon	Under Dry Creek	150
Enterprise Canal	At Herndon Canal	90
Gould Canal	Mud Creek to Del Rey Avenue	200 4/
Gould Canal	Del Rey Avenue to Redbank Creek	300
Gould Canal Siphon	Under Redbank Creek	150
Gould Canal	Redbank Creek to Dry Creek	150 4/
Fresno Canal	Kings River to Mill Ditch	2000

1/ Represents channel capacities that range from 300 cfs just below the Enterprise Canal to 400 cfs at McKinley Ave.
2/ Represents channel capacity from 90 cfs in its primary channel to 300 cfs in its secondary overbank channel. Several owners have encroached into this area.
3/ The first value represents actual outlet capacity; the second is the bank full capacity of the channel.
4/ Represents the maximum estimated bank full capacity.
5/ See Plates H2 and H6 for locations.

metropolitan area. They include Big Dry Creek Reservoir and diversion channel, located northeast of Clovis; Redbank Creek Dam, located east of Fresno; and numerous flood detention/ground water recharge facilities located in the Fresno-Clovis Area. These developments provide protection to portions of the metropolitan area. The Fresno Metropolitan Flood Control District Master Plan calls for additional detention basins to be built and integrated into its system. These facilities temporarily store peak urban runoff that existing drainage channels cannot handle safely. Using a series of pumping stations and channels, the stored water is moved out of the city by way of

the Herndon Canal, Dry Creek, or Fancher Creek. The flood waters eventually enter the San Joaquin River or stay on the valley floor west of Fresno. The proposed Redbank and Fancher Creeks project consist of the following flood control facilities:

a. Big Dry Creek Reservoir enlargement - to provide increased flood protection on Dry Creek.

b. Fancher Creek Dam - to provide storage on Fancher Creek and divert Redbank Creek tributaries east of Madsen Avenue to Fancher Creek Reservoir, east of the Friant-Kern Canal.

c. Redbank Creek Detention Basin - to provide temporary storage for peak local runoff for areas upstream of Mill Ditch.

d. Pup Creek Detention Basin - to provide temporary storage for peak local runoff for areas east of Temperance Avenue on Pup Creek.

e. Alluvial Drain Detention Basin - to provide temporary storage for peak local runoff for areas east of the Enterprise Canal on Alluvial Drain.

5. Vegetation. - The areas directly above the Friant-Kern Canal are predominantly well-managed grasslands used mostly for grazing. Grass cover shares the higher elevations with scattered brush and stands of Blue Oak. In the highest part of the Dry Creek watershed, the woody cover of oak trees and brush is more extensive. The land below the Friant-Kern Canal includes a wide range of agricultural, rural, and urban environments. The areas north and east of Clovis and to the east of Fresno are of flat valley agricultural type consisting mainly of orchards, vineyards, pastures and field crops. The rural and semi-rural areas include many small farms and ranchettes, the latter usually being about 2 to 5 acres in size. Fresno County's Master Plan has limited eastward urban development to Temperance Avenue. This is also the effective westward project boundary of the Redbank and Fancher Creeks Project.

6. Topography. - The topography of the study area ranges from the moderate to steep hills and ridges of the Sierra foothills to the nearly flat alluvial plains of the eastside valley. The highest elevation is 4,700 feet in the Dry Creek headwaters, while the lowest is 350 feet on Mill Ditch southeast of Clovis, Plate H3. The alluvial fan area south and west of the foothills consists of material deposited by the streams draining the foothills between the San Joaquin and Kings Rivers. The alluvial terrain is gently rolling on the terraces bordering the foothills and nearly level just east of Clovis.

7. Climate. - The climate of the area is semi-arid, with hot, dry summers and cool, moist winters. Fog can occur frequently in December and January, when a high pressure system traps marine air in the valley. The foggy periods sometimes last longer than two weeks. The fog layer can be several hundred feet thick, but above it the mountains have clear skies and mild temperatures.

In the valley, winds generally come from either direction of the northwest-southeast axis of the San Joaquin Valley, with northwest winds prevailing for most of the year. In the foothills, the air flows are usually upslope in the afternoon and downslope at night. The strongest winds occur in association with winter storms.

8. Temperature. - During the summer, the Coast Range blocks the flow of cooling marine breezes; the normal daily maximum temperature rises to near 100° Fahrenheit (F) during the latter part of July. Except for infrequent cold spells, winter daytime temperatures are substantially above freezing. Heavy frosts occur almost every year between November and March. Temperature extremes observed in the area have ranged from 17°F to 116°F. Average temperatures drop about 3°F for every thousand feet of elevation above the valley floor. Average monthly temperatures for four representative stations are tabulated on Table H-2.

Table H-2

Mean Monthly Temperatures
(°F)

Month	Auberry 1NW 1 (EL. 2140 ft.)	Fresno WSO AP 1/ (EL. 328 ft.)	Friant 1/ Govt. Camp (EL. 410 ft.)	Pine 2/ Flat Dam (EL. 615 ft)
January	44.3	45.5	45.3	44.7
February	47.2	50.5	49.8	49.8
March	49.3	54.3	52.6	52.9
April	54.8	60.1	58.0	58.2
May	63.1	67.7	65.9	66.1
June	71.6	75.0	73.7	74.0
July	79.5	81.0	80.5	80.2
August	77.5	78.9	78.7	79.1
September	72.6	74.1	73.7	74.0
October	62.7	64.8	65.1	64.6
November	51.4	53.2	53.7	52.9
December	45.3	45.3	45.8	45.7
Annual	59.9	62.5	61.9	61.8

1/ Average temperature for 1951 - 1980.
2/ Average temperature for 1953 - 1982.

9. Precipitation. - Average annual precipitation over the study area varies from 10.5 inches east of Fresno to above 30 inches in the headwaters of Dry Creek. Most of this precipitation occurs between November and April. Thundershowers may move into the area during the summer. Winter precipitation usually falls as rain, though snowfall may occur down to 2,000 feet and occasionally lower. The climatological stations used in this study are listed on Table H-3. Plate H4 presents station locations and normal annual precipitation isohyetal lines. Average monthly and annual precipitation amounts for four representative stations are tabulated on Table H-4.

10. Streamflow Data. - The only streamflow data available for the project area are from Dry Creek near Academy, and Dry Creek at Big Dry Creek Reservoir. Both stations are maintained by the Fresno Irrigation District.

Their monthly flows are shown in Tables H-5 and H-6. Almost 90% of the runoff occurs during a five months period between December 1 and May 1. Both Dry Creek stations and other gauge stations located just outside the study area, along with the major floods of record, are listed in Table H-7. The locations of the stations on Dry and Little Dry Creeks are shown on Plate H1.

11. Storm Characteristics. - Flood producing storms covering the project area stream basins occur as rain during October through April. The majority of these storms occur from the latter part of December to the first part of April. There are two distinct types of storms: general storms that produce widespread heavy precipitation, and local storms that produce extremely heavy short-term precipitation over small areas.

The widespread rains experienced during general storms result from the combined effect of orographic lift and convergence. These storms usually last from one to four days. During these frontal waves, there are usually several periods of high rainfall rates lasting several hours. The basin-wide precipitation pattern may vary considerably during a particular storm, and from one storm to another.

Local or cloudburst storms usually last from one to six hours and vary in extent from a few square miles to less than one hundred square miles. Two basic kinds of cloudburst storms are characteristic of this meteorological region. The first kind results from convection activity during summer months. These storms fall on dry ground and have not caused significant flooding. The second kind of cloudburst storm occurs during the winter rainy season in association with general storms. They result from convection cells triggered by local convergence. Most of these local storms are relatively small and not easily distinguished from small general storms. If these hot cells are imbedded in a large general storm, severe flooding will occur.

12. Flood Characteristics. - Floods from foothill streams in the Fresno area result from large general rainstorms that occur during the late fall and winter or from cloudburst storms occurring during late spring or early fall. Snowmelt is not critical on these lower elevation streams. General rainfloods last several days and are characterized by high peak discharges and relatively small volumes when compared with snowmelt floods or general rainfloods on larger basins. Cloudburst floods are characterized by extremely high peak-to-volume ratios. They are confined to relatively small areas, and consequently have small volumes.

13. Historic Floods. - Detailed information on early historical floods that have occurred in Fresno County is limited to newspaper accounts because streamflow records are not available. The earliest streamflow records in the County were collected on the Kings River at Piedra (below Pine Flat Dam) beginning in 1895 and on the San Joaquin River below Friant beginning in 1907. Records on Dry Creek and Dog Creek began in the early 1940's, but the Dog Creek station closed in 1947.

Table H-3

Climatological Stations

STATION	County	Lat.	Long.	Elev. (Ft. MSL)	NAP (in.)	Period of Record
Academy	Fresno	36°53'	119°33'	545	13.8	1958 to date
Auberry 1NW	Fresno	37°05'	119°30'	2140	23.8	1916 to date
Big Dry Creek Res.	Fresno	36°53'	119°40'	400	12.1	1948 to date
Clovis 7NE	Fresno	36°54'	119°40'	404	12.3	1917 to 1947
Fresno WSO AP	Fresno	36°46'	119°43'	328	10.5	1878 to date
Friant Govt. Camp	Fresno	36°59'	119°43'	410	13.7	1902 to date
Huntington Lake	Fresno	37°14'	119°13'	7020	32.1	1914 to date
Lemon Cove	Tulare	36°23'	119°02'	513	13.3	1899 to date
Meadow Lake	Fresno	37°05'	119°26'	4485	30.1	1948 to 1976
Piedra	Fresno	36°49'	119°23'	580	16.4	1917 to 1964
Pine Flat Dam	Fresno	36°49'	119°20'	610	18.1	1952 to date
San Joaquin Exp Range	Madera	37°05'	119°43'	1050	17.7	1940 to date
Three Rivers PH No. 2	Tulare	36°28'	118°53'	950	19.8	1909 to 1971

Table H-4

Mean Monthly Precipitation
(Inches)

Month	Auberry 1NW 1/ (EL. 2140 ft.)	Fresno WSO AP 1/ (EL. 328 ft.)	Friant Govt. Camp 1/ (EL. 410 ft.)	Pine Flat Dam 2/ (EL. 615 ft)
January	4.60	2.05	2.51	3.77
February	4.01	1.85	2.29	2.91
March	3.57	1.61	2.04	2.78
April	2.60	1.15	1.50	1.91
May	0.82	0.31	0.47	0.58
June	0.16	0.08	0.12	0.15
July	0.04	0.01	0.12	0.03
August	0.04	0.02	0.02	0.02
September	0.44	0.16	0.27	0.25
October	0.91	0.43	0.59	0.67
November	2.61	1.24	1.67	2.00
December	4.04	1.61	2.23	3.04
Annual	23.84	10.52	13.73	18.11

1/ Average precipitation for 1951 - 1980.
2/ Average precipitation for 1953 - 1982.

A brief general description of the relative magnitude and extent of large floods for the period 1861 to 1907 is contained in USGS Water Supply Paper 843. Based on information in that publication, it is apparent that flooding occurred in Fresno County during the winters of 1861-62, 1867, 1884, 1886, 1890, and 1906. Since 1907, extensive flooding occurred in Fresno County in 1914, 1916, 1937, 1955, 1958, 1966, and 1969.

The most recent period of extensive flooding with high peak flows in Fresno County occurred in 1969. Intense and prolonged precipitation over the area resulted in widespread flooding throughout the County in late January and late February. Detailed information regarding this flood is available in the Sacramento District's "Report on Floods, Central Valley of California, 1968-69 Flood Season," dated August 1970. The rainflood season of 1982-83 yielded the greatest volume of flow into Big Dry Creek Reservoir. This runoff resulted from a greater number of moderate intensity storms, which produced minor street flooding in the city of Fresno and some sheet flooding below the Friant-Kern Canal. Some recorded maximum peak flows that have occurred in and around the project area are shown in Table H-7.

14. <u>Sedimentation and Erosion</u>. - The San Joaquin Basin experiences moderate to severe erosion problems. Generally, sheet and gully erosion affects the foothills and mountains, while wind erosion and poorly managed agricultural practices affect the flat valley floor regions. Although the contributing area is extensive, the sediment yield from the valley floor is quite low (SCS, November 1977). In the foothills and mountains, sheet and gully erosion can be a major problem. However, foothill areas east of Fresno experience far less sheet and gully erosion problems compared to other foothill regions in the San Joaquin Valley.

The vegetative cover on range and forest land is generally good in this portion of the Sierra foothills. Agricultural uses of the drainage areas above the Big Dry Creek Reservoir and Fancher Creek Reservoir site are almost exclusively for grazing. This rangeland is well-managed and not overgrazed. Supplemental seeding programs are implemented in the fall to help decrease erosion while providing extra feed for the cattle.

The Soil Conservation Service report, "San Joaquin Valley Basin Study, California" (Nov 1977), presented average sediment yield for five broadly defined areas in the San Joaquin Valley Basin. Average sediment yields for the SCS study were determined from existing project areas and application of the Universal Soil Loss Equation to certain areas.

Table H-8 presents an average annual sediment yield and an expected range for the annual yield.

Plate H5 shows a table of reservoir sedimentation for the east side of the San Joaquin River Basin and a map showing the locations of these sediment reaches. These data are a compilation of data from the SCS November 1977 report and the "Sediment Deposition in U.S. Reservoirs - Summary of Data Report through 1980", (USGS, May 83). The average annual sediment yield for these east side reservoirs was 0.15 AF/mi^2. Based on a visual inspection of the project area and this data it was assumed that the average annual yield for Big Dry Creek and Fancher Creek Reservoirs is 0.15 AF/mi^2.

HYDROLOGY APPENDIX
TABLE H-5

RECORDED MONTHLY AND ANNUAL
INFLOW TO DRY CREEK RESERVOIR
DRAINAGE AREA 81.68 SQUARE MILES

WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	ANNUAL
					(FLOW IN ACRE FEET)								
1949	N/R	N/R	N/R	0	0	170	30	0	N/R	N/R	N/R	N/R	
1950	N/R	N/R	N/R	0	380	0	0	0	0	0	0	0	
1951	0	620	1520	1040	570	220	0	0	0	0	0	0	3970
1952	0	0	440	5900	1930	7390	2000	560	20	0	0	0	18240
1953	0	0	380	1220	220	220	0	0	0	0	0	0	2040
1954	0	0	30	150	200	0	0	0	0	0	0	0	380
1955	0	0	580	0	320	0	0	0	0	0	0	0	900
1956	0	0	10540	7240	2790	1060	670	1010	100	0	0	0	23410
1957	0	0	100	100	100	0	0	0	0	0	0	0	300
1958	0	0	230	2010	5230	7390	810	0	0	0	0	0	15670
1959	0	0	0	0	970	80	0	0	0	0	0	0	1050
1960	0	0	0	0	300	0	0	0	0	0	0	0	300
1961	0	0	0	60	80	60	0	0	0	0	0	0	200
1962	0	0	0	0	5580	1060	10	0	0	0	0	0	6650
1963	0	0	0	150	920	410	1170	60	0	0	0	0	2710
1964	0	0	0	0	0	130	70	0	0	0	0	0	200
1965	0	0	380	1940	470	370	2470	0	0	0	0	0	5630
1966	0	0	80	200	100	0	0	0	0	0	0	0	380
1967	0	0	920	950	360	1920	8040	1500	140	0	0	0	13830
1968	0	0	50	80	70	0	0	0	0	0	0	0	200
1969	0	0	0	13680	15380	9160	4190	1270	1090	0	0	0	44770
1970	0	0	50	2270	490	1580	60	0	0	0	0	0	4450
1971	0	0	1080	530	270	200	0	0	0	0	0	0	2080
1972	0	0	0	0	0	0	0	0	0	0	0	0	0
1973	0	0	0	190	3730	4080	780	270	0	0	0	0	9050
1974	0	0	0	1160	170	2040	2230	210	0	0	0	0	5810
1975	0	0	0	0	320	1760	360	20	0	0	0	0	2460
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	2610	12180	1780	8180	3880	660	0	0	0	29290
1979	0	0	0	210	1590	2900	1390	570	0	0	0	0	6660
1980	0	0	0	1580	5890	4370	3950	300	0	0	0	0	0
1981	0	0	0	0	0	240	120	0	0	0	0	0	360
1982	0	0	0	750	990	5770	5930	560	0	0	0	0	14000
1983	0	2000	3950	10670	15330	25050	6520	2430	160	0	0	0	66110
YEARS OF RECORD	33	33	33	35	35	35	35	35	34	34	34	34	33
TOTAL		0	2620	20330	54690	76930	79410	48980	12640	2170	0	0	0
MAXIMUM	0	2000	10540	13680	15380	25050	8180	3880	1090	0	0	0	66110
MINIMUM	0	0	0	0	0	0	0	0	0	0	0	0	0
AVERAGE	0	79	616	1563	2198	2269	1399	361	64	0	0	0	8549

Notes: Inflow equals the sum of the outflow plus the change in storage above elevation 400.00 feet. Storage fluctuations below elevation 400 feet are not recorded. The average annual inflow is the sum of the average monthly inflows.

TABLE H-6

RECORDED MONTHLY AND ANNUAL RUNOFF
DRY NEAR ACADEMY
DRAINAGE AREA 44.00 SQUARE MILES

WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR (FLOW IN ACRE FEET)	APR	MAY	JUN	JUL	AUG	SEP	ANNUAL
1942	212	230	1510	1840	1460	1350	912	568	142	24	8	6	8262
1943	6	175	323	1470	1090	2600	780	317	67	4	0	0	6832
1944	14	69	202	262	1728	1589	543	373	77	0	0	0	4857
1945	0	8	44	186	4866	3243	1091	153	18	0	0	0	9609
1947	0	608	579	104	134	66	22	0	0	0	0	0	1513
1949	0	0	0	131	456	1367	278	14	0	0	0	0	2246
1950	0	0	0	246	756	248	261	24	0	0	0	0	1535
1951	0	1960	1730	1400	1080	1080	274	216	0	0	0	0	7740
1952	0	0	1704	3671	926	5177	3420	1536	755	0	0	0	17189
1953	0	0	2154	2154	490	486	395	615	224	0	0	0	6518
1954	0	0	145	405	726	853	303	58	0	0	0	0	2490
1955	0	0	179	1114	319	222	204	272	0	0	0	0	2310
1956	0	0	9443	2253	1766	1196	1180	1037	190	0	0	0	17065
1957	0	198	381	460	379	325	165	294	89	0	0	0	2291
1958	0	0	173	246	1985	2289	4614	859	151	0	0	0	10317
1959	0	99	226	232	1045	450	210	50	0	0	0	0	2312
1960	0	0	20	244	587	264	210	46	0	0	0	0	1371
1961	0	0	0	218	216	210	85	0	0	0	0	0	729
1962	0	0	0	24	8529	2057	76	103	0	0	0	0	10789
1963	0	0	0	662	2034	1285	1154	210	24	0	0	0	5369
1964	0	210	139	206	232	383	410	135	0	0	0	0	1715
1965	0	0	793	3193	904	776	3683	518	64	0	0	0	9931
1966	0	127	543	891	692	280	83	0	0	0	0	0	2616
1967	0	0	1527	1537	1222	2146	5153	1694	367	8	0	0	13654
1968	0	129	300	304	276	216	282	134	0	0	0	0	1641
1969	0	0	317	9052	8557	12040	7530	2995	1208	666	284	286	42935
1970	528	577	746	2063	990	1916	716	351	0	0	0	0	7887
1971	0	325	1968	974	575	659	518	590	159	0	0	0	5768
1972	0	0	616	587	621	272	86	5	0	0	0	0	2187
1973	0	0	196	712	1931	2772	750	179	0	0	0	0	6540
1974	0	119	537	1852	416	982	2233	171	0	0	0	0	6310
1975	0	0	313	290	317	1047	417	119	0	0	0	0	2503
1976	0	0	167	185	323	274	153	6	0	0	0	0	1108
1977	0	0	0	99	131	196	47	0	0	0	0	0	473
1978	0	0	234	2400	6904	6032	3668	1805	1013	0	0	0	22056
1979	0	129	370	1379	2329	4802	1611	516	128	0	0	0	11264
1980	0	71	282	1182	1904	2953	1464	887	175	0	0	0	8918
1981	0	0	183	331	682	843	1029	87	0	0	0	0	3155
1982	0	22	401	2390	909	5345	7351	821	28	0	0	0	17267
1983	0	3519	2945	7692	8429	12152	3566	2866	698	123	123	123	42236
YEARS OF RECORD	40	40	40	40	40	40	40	40	40	40	40	40	40
TOTAL	760	8575	31390	54641	68916	82443	56927	20624	5577	825	415	415	331508
MAXIMUM	528	3519	9443	9052	8557	12152	7530	2995	1208	666	284	286	42935
MINIMUM	0	0	0	24	131	66	22	0	0	0	0	0	473
AVERAGE	19	214	785	1366	1723	2061	1423	516	139	21	10	10	8288

Notes: There are no data for water years 1946 and 1948. December 1978 was estimated from incomplete records. The average annual flow is the sum of the average monthly flows.

Table H-7

Recorded Maximum Peak Stream Flows

Station	Drainage Area (sq. mi.)	Period of Record	Max Floods of Record (Date)	Peak Flow (cfs)
Dry Creek at Academy	44.0	Jan 41 to date	25 Jan 69	4,400
Little Dry Creek near Friant	57.9	Oct 41 to Sep 56	24 Dec 55	1,760 1/
Little Dry Creek at Mouth, near Friant	77.7	Oct 56 to date	22 Mar 58	4,700
Cottonwood Creek near Friant	35.6	Oct 41 to date	24 Feb 69	3,300
Big Dry Creek Reservoir	81.6	Oct 49 to date	25 Jan 69	5,700

1/ Estimated

Table H-8

Estimated Sediment Yields
San Joaquin Valley Basin
(from SCS, November 1977)

Regional Area	Estimated Average Annual Sediment Yield (Acre Feet per Square Mile per Year)	Expected Range in the Annual Yield (Acre Feet per Square Mile per Year)
East side of Coast Range & Tehachapi Mts.	0.30	0.20-0.50
West Side Fans	0.15	0.10-0.20
Central Valley	0.05	0.00-0.10
East Side Fans	0.20	0.10-0.20
Sierra Nevada Mountains	0.25	0.10-0.30

The area between the Friant-Kern Canal and the project detention basins is zoned Agricultural or Rural Residential and is characterized by flat slopes and leveled fields. In the Feasibility Report the sediment yield for areas above Redbank Creek, Pup Creek, and Alluvial Drain Detention Basins was assumed to be 0.05 acre feet per square mile per year.

To confirm the Feasibility Report average annual sediment yield estimate of 0.05 AF/mi^2, SPK put under contract the Department of Civil Engineering, California State University, Fresno, in 1983, to take suspended load sediment

samples at three locations on Redbank Creek during high water periods. Plate H1 shows the sediment sample sites as staff gages 7 through 9. The three locations are: Redbank Creek above Redbank Reservoir, Redbank Creek below the Reservoir at Shaw Avenue, and Redbank Creek below the Reservoir at the Redbank Creek Detention Basin site (DeWolf Avenue).

Samples were taken at these locations seven times during the year. The estimated average suspended sediment load for all events was less than 0.01 AF/mi^2. The 100-year reservoir and detention basin sediment accumulation due to these sediment yeilds are shown in Table H-9.

Table H-9

100-Year Reservoir and
Detention Basin Sediment
Accumulation

Accumulation	Drainage Area (sq.mi.)	Contributing Area (sq.mi.)	Annual Sediment Year AF/mi 2/Yr	Trap Efficiency (%)	100 year Sediment (Ac.Ft.)
Reservoirs					
Big Dry Creek	81.68	78.68	.15	95	1,120
Fancher Creek	27.83	27.83	.15	95	396
Detention Basins					
Redbank Creek	25.17	11.30	.05	20	11.3
Pup Creek	4.26	2.32	.05	95	11.0
Alluvial Drain	2.65	2.65	.05	95	12.6

The trap efficiency value of 20% in Table H-9 for Redbank Creek Detention Basin is thought to be Conservative because: 1) Channel invert is below Basin invert; the only bed load deposition would occur in the channel, 2) Sediment samples from drill logs taken in the area are 60% sand and 40% fines thus only a portion of fines that were suspended would enter Redbank Creek Detention Basin, and 3) Over half of the daily flows from Redbank Creek will stay in the channel and not enter the Basin area.

Estimates of the sediment distribution in Big Dry Creek Reservoir and Fancher Creek Reservoir site were made using ETL-1110-2-64, dated 7 July 1969 and verified with the Flood Pool index method given in HEC-1 HD-1200, Vol. 12, Sec 5.05.

This empirical method attempts to account for the influences of reservoir regulation inherent in a pool-elevation duration curve, general effects of the fraction of sand materials involved, and the size and shape of the reservoir. The approach is based upon the idea that pool elevation and size characteristics of the sediment are two of the most important factors

influencing deposition in given elevation zones. It also embodies the thesis that: (1) over a long period of time, sediment delivered by medium and moderate floods will establish some statistical order of coincidence with pool elevations between the maximum and minimum, and (2) that regulation of the rare floods (and therefore, the distribution of sediment deposited in the higher elevation zones) will be similar. This suggests that there may be some reasonably definable relationships between duration of a given pool and the amount of sediment that will be deposited above and below the elevation of that pool. This index method is based upon limited data and its reliability for general application will require much more testing.

The results of the sediment distribution analysis are shown in Table H-10. Figures H-1 and H-2 show pool - elevation duration and sediment deposition as percentages versus pool elevation in feet for the Big Dry Creek and Fancher Creek Reservoirs, respectively. These curves were instrumental in developing the data in Table H-10. The pool - elevation duration curve represents the percent of time in which the pool is at or above a given elevation. The sediment deposition curve shows the percent of the total 100 year sediment volume that will be deposited at or below a given elevation.

15. Subareas. - Modeling a hydrologically complex basin like the Redbank-Fancher Creek study area requires the basin to be broken down into subareas. The watershed area under study was divided into many small subareas using artificial and natural physical features, such as canal and road crossings as key locations for flow computations. Subarea boundaries are indicated on Plate H2. Great care was taken to delineate drainage area boundaries for the stream channels and immediate overbank areas. These subareas were drawn from contour lines on USGS 7.5 minute series maps, large scale 1:9600 maps with two-foot contour intervals, provided by the Fresno County Planning Department, and field inspection. Consequently, some of the drainage areas and flow patterns differ from what was presented in the hydrology section of the Feasibility Report. These differences did not affect flood plains below the projects. The drainage areas are described by outflow map location in terms of township, range, and section number. The agricultural areas below the Friant-Kern Canal, some which were recontoured, have no defined drainage channels and were separated and treated differently from those drainage areas immediately adjacent to the mainstream channels.

16. Flood Reconstitutions. - A detailed analysis of the precipitation and runoff data was made for the Feasibility Study for the floods of December 1955, March 1958, January 1969, and February 1969, on Dry Creek, Little Dry Creek, and Cottonwood Creek basins. The results of these analyses are discussed in previous hydrology studies (reference c, and d.).

17. Unit Hydrographs. - The unit hydrograph procedures and data approved for use in the Feasibility Study were used in these GDM studies. In order to justify any changes in the unit hydrograph parameters used in this GDM, the analysis of floods of equal or greater magnitude would have to show major differences in their reconstituted hydrograph parameters. To date no floods equal to or greater than those used in the reconstitution studies have occured.

Table H-10

Reservoir Sediment Distribution and Storage Capacity

Big Dry Creek Reservoir

Elevation (Feet)	Initial Reservoir Capacity (Ac-Ft)	100 Yr Sediment Volume (Ac-Ft)	Final Reservoir Capacity (Ac-Ft)
396	0	0	0
400	216	40	176
405	956	120	836
410	2399	240	2159
415	5139	420	4719
420	9779	710	9069
425	16,429	980	15,449
430	25,014	1,090	23,924
432.6	30,194	1,120	29,078

Fancher Creek Reservoir

Elevation (Feet)	Initial Reservoir Capacity (Ac-Ft)	100 Yr Sediment Volume (Ac-Ft)	Final Reservoir Capacity (Ac-Ft)
454	0	0	0
460	250	33	217
465	1,160	120	1,040
470	2,861	230	2,631
475	5,595	350	5,245
480.5	10,304	396	9,908

The L.A. S-graph Method was used to develop the unit hydrographs for all of the subbasins. An average foothill S-curve, developed from unit hydrographs optimized from the flood reconstitutions discussed in references d and e, was used for the foothill areas, and the L.A. Valley S-curve was used for all valley areas. The S-curves used are shown on Figure H-3. Lag relationships are shown on Figure H-4. A table of unit graph parameters and unit hydrographs for subbasins used for the 200 year and Standard Project Flood (SPF), and those used for the Probable Maximum Flood (PMF) are shown in Table H-11 and Table H-12. The n values adopted for use were based on a field inspection of the area and a comparison with values estimated for the gauged areas from the flood reconstitutions. The following n values were used: 0.05 in the foothill areas above the Friant-Kern Canal; 0.20 for the non-urbanized valley agricultural areas; 0.05 for the fully urbanized areas (valley) and 0.05 - 0.20 for the areas that belong to intermediate categories. The n value for the PMF unit hydrographs in most cases was decreased by twenty percent to reflect the increased hydraulic efficiency of the basins during this larger flood.

18. Loss Rates. - The initial and constant loss-rate method was used for the GDM studies. The ground was assumed saturated before the start of the project storm (4th of the six 5-day waves) therefore the initial loss was assumed equal to the constant loss. Greater initial losses are experienced

BIG DRY CREEK RESERVOIR
DISTRIBUTION OF SEDIMENT DEPOSITS

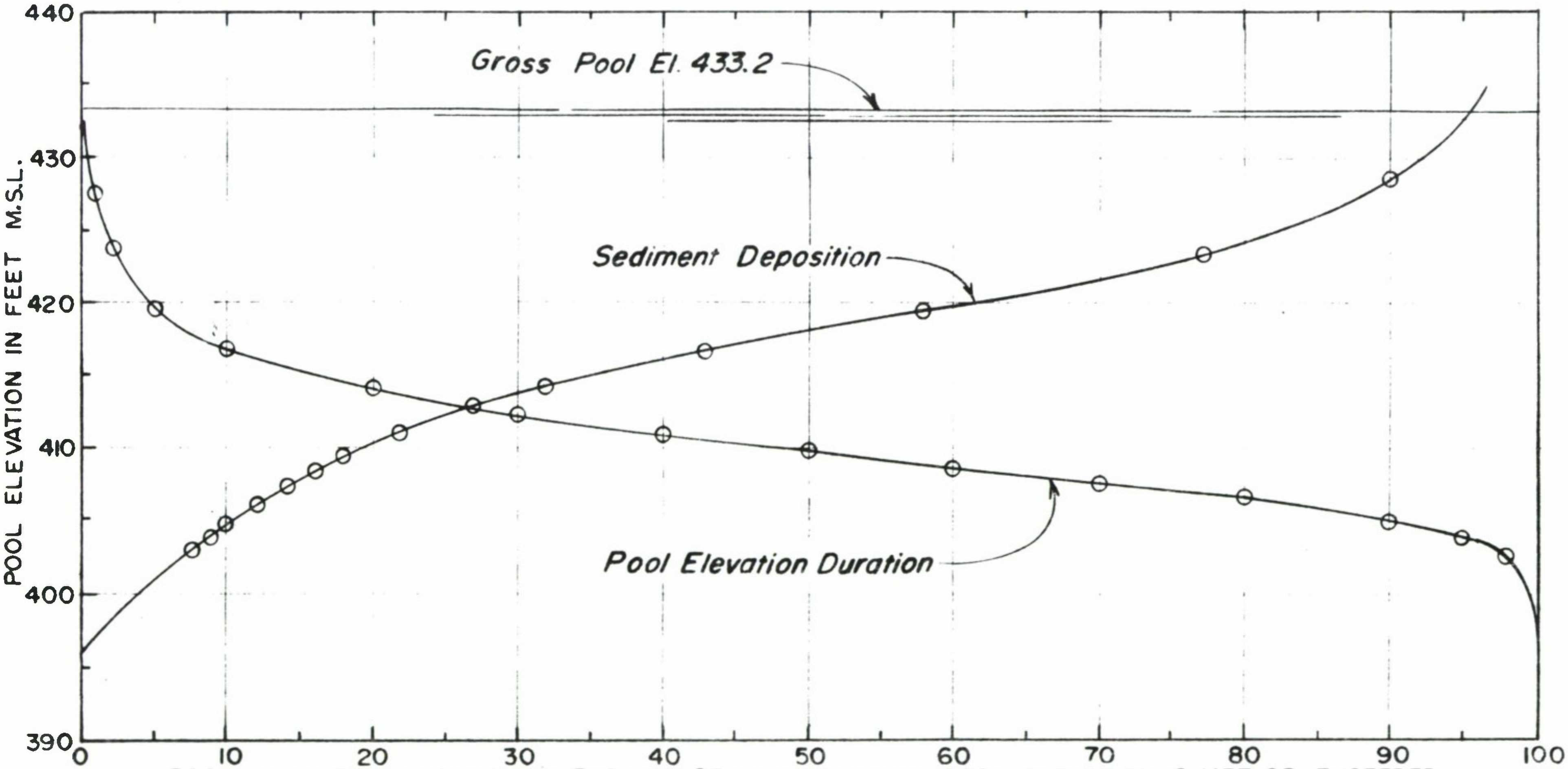


FIGURE H-1

FANCHER CREEK RESERVOIR
DISTRIBUTION OF SEDIMENT DEPOSITS

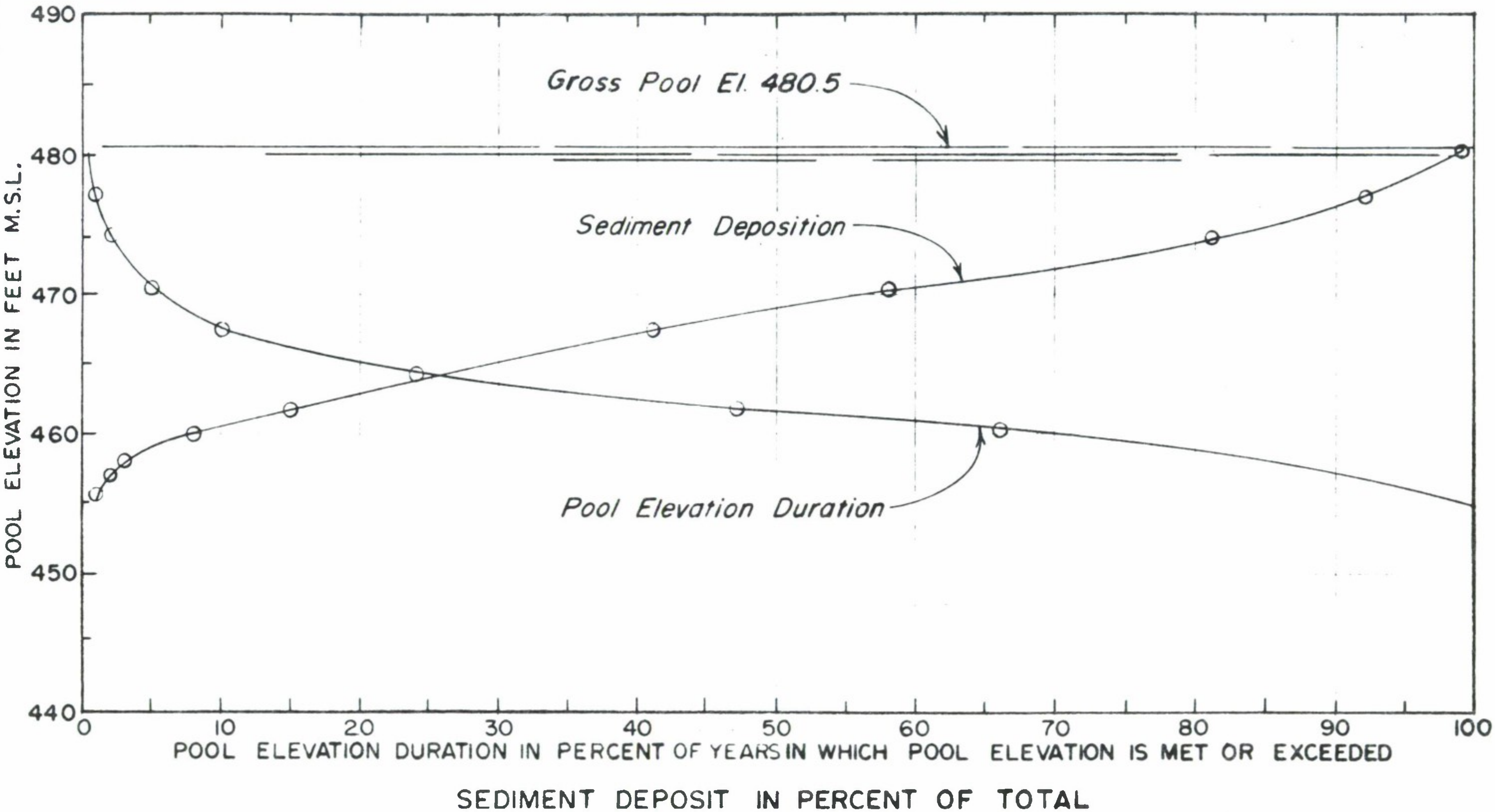


FIGURE H-2

for recontoured agricultural areas not adjacent to mainstream channels. Because the recontouring effect on these areas is significant, the run off from these areas was assumed to be zero for the first two of the six 5-day waves. All these areas lie between the Enterprise and Fresno Canals. The constant loss rates developed for the subareas within the study area were based on flood reconstitutions in the foothill areas of Dry Creek (reference 2d), the general soil maps prepared by the U.S. Soil Conservation Service for the eastern Fresno Area in 1971, their Hydrologic Classification of Soil Series, and a field inspection of the study area. The subarea loss rates are listed in Table H-13.

19. Base Flow - As presented in the Feasibility Report, a constant base flow of 4 cfs/sq. mi. is used for the main wave of the project design floods. This value is the result of the flood reconstitutions previously mentioned.

20. Project Storms. - Both cloudburst and general rainstorms were examined to determine the critical type of storm for project design flood computations. The cloudburst runoff from the areas above the project features had higher peak flows but only a fraction of the volume of the general rain floods. The only areas between the Friant-Kern Canal and the planned flood control features that would contribute to cloudburst runoff are those narrow subareas immediately adjacent to the stream channels. Consequently it was determined that the general rain storm covering the entire area produced the most critical flood runoff, peak and volume for the study area.

Two different 96-hour storms were used to develop the project design floods: the Standard Project Storm (SPS) for Big Dry Creek Dam and diversion, and a 200-year storm for the other facilities. Standard Project Storm amounts computed previously for Dry Creek were in accordance with the Sacramento District's 1971 Standard Project Rainflood criteria. The time distribution is from the same report. The precipitation distribution is shown on Table H-14.

Storm amounts for the 200-year storm were based on regionalized four-day rainfall frequency curves from several recording gauges in and around the project area. These data are found in Rainfall Analysis for Drainage Design Volume II, Long-Duration Precipitation Frequency Data", Bulletin No. 195, published by the State of California's Department of Water Resources, October 1976 with updated data through 1980. Rainfall depths for the different drainage areas were taken from curves developed from the 200 year 4-day depths verses normal annual precipation. This curve is shown on Figure H-5. For comparison, the 96-hour Standard Project Storm amounts from the Appendix and previous Redbank and Fancher Creeks feasibility reports and for subareas are plotted on the same Figure. Plate H6 shows the NAP map and locations of the stations used. Table H-13 lists both the SPS and 200-year storm amounts for the drainage areas. The time distributions for the storms of December 1938, December 1955, February 1962, and January and February 1969 at the Fresno APNWS station were reviewed and compared favorably with the SPS distribution.

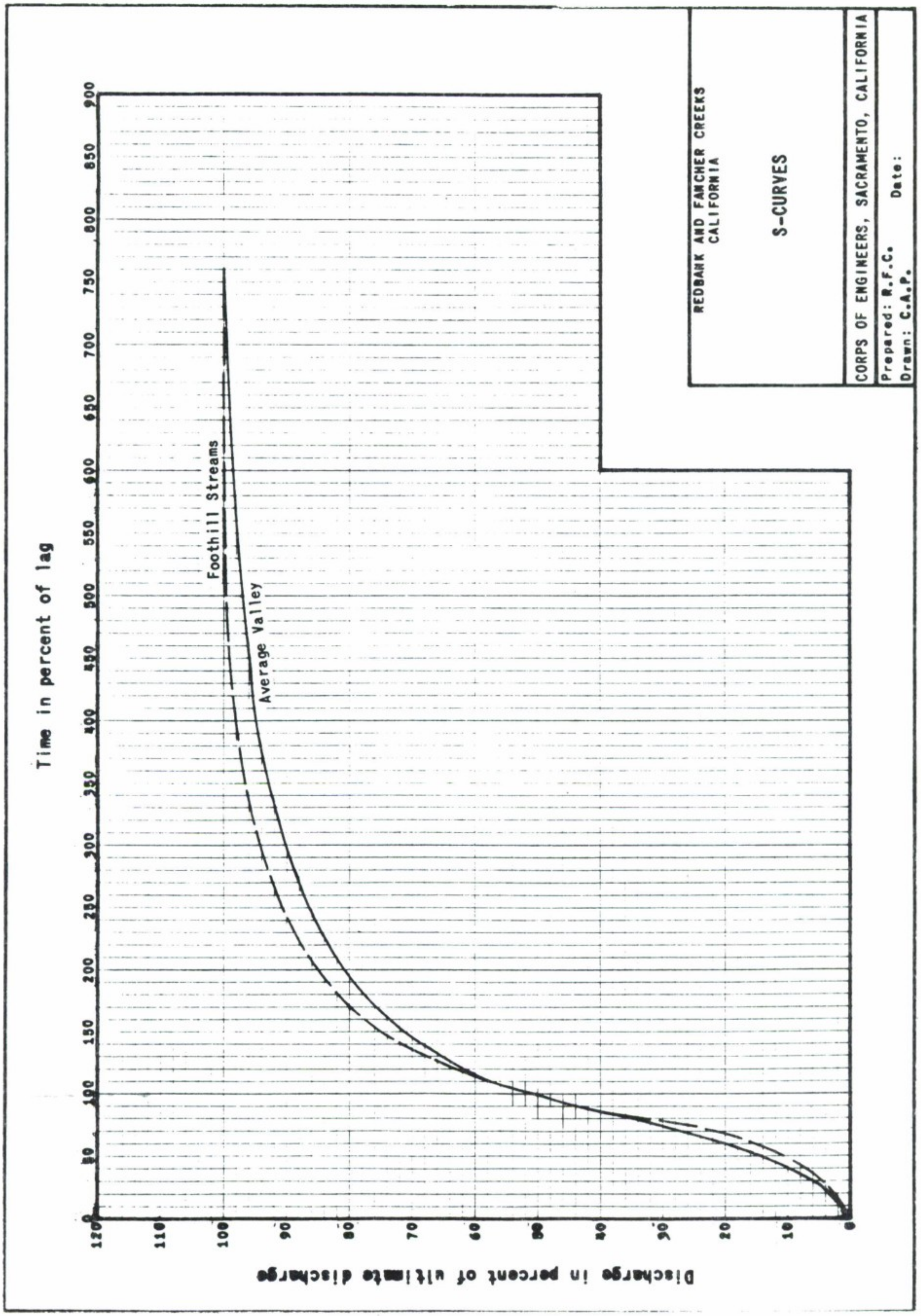
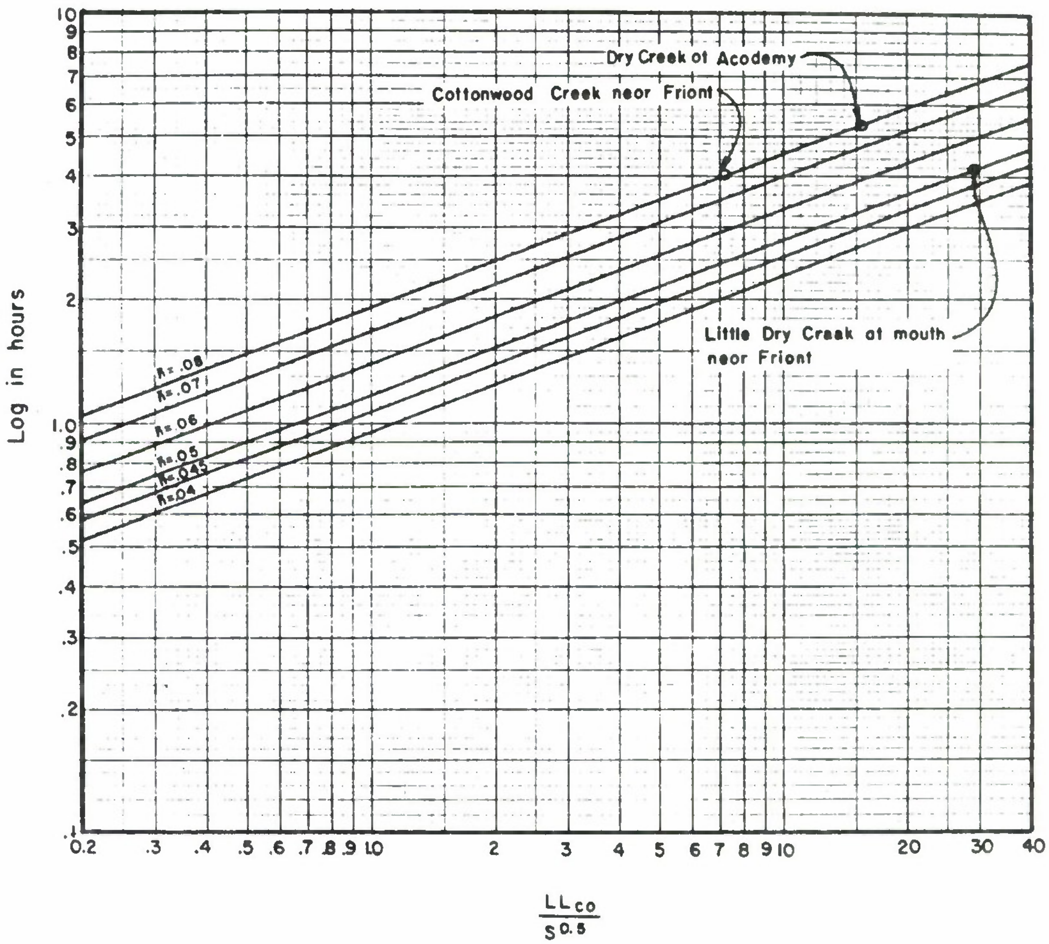

REDBANK AND FANCHER CREEKS
CALIFORNIA
S-CURVES
CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA
Prepared: R.F.C. Date:
Drawn: C.A.P.
Time in percent of lag
0 50 100 150 200 250 300 350 400 450 500 550 600 650 700 750 800 850 900
Discharge in percent of ultimate discharge
120 110 100 90 80 70 60 50 40 30 20 10 0
Foothill Streams
Average Valley

FIGURE H-3



TERMINOLOGY

L	-	Length of longest watercourse.
L_{ca}	-	Length along longest watercourse, measured upstream to point opposite center of area.
S	-	Overall slope of longest water-course between headwater and collection point.
Lag	-	Elapsed time (in hours) from the beginning of an assumed continous series of unit effective rainfalls over the area to the instant at which the rate of the resulting run-off at the area concentration point equals 50 percent of the maximum (ultimate) rate of the resulting run-off at that point.
$\bar{n}$		Visually estimated mean of the n (Manning's Formula) values of all the channels within an area.

REDBANK AND FANCHER CREEKS
CALIFORNIA

LAG RELATIONSHIPS

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: R.F.C.
Drawn: C.A.P.
Date:

FIGURE H-4

TABLE H-11

STANDARD PROJECT AND 200-YEAR FLOODS
UNIT HYDROGRAPH CHARACTERISTICS
AND ORDINATES FOR
DRY, REDBANK, FANCHER CREEKS AND CANAL SYSTEMS

	MUD CREEK				FANCHER CREEK					
SUBAREAS	331730	331920	232540	232541	222640	223540	230210	231220	231330	232620
CHARACTERISTICS										
D.A. (sq. mi.)	6.16	0.70	0.39	1.02	1.88	2.05	3.05	20.87	0.80	0.82
L (mi.)	3.77	1.17	1.82	1.78	2.88	3.64	4.35	11.24	1.85	2.18
Lca (mi.)	1.61	0.72	1.00	0.97	1.67	2.24	1.97	5.13	0.89	1.04
Delta H. (ft)	263	17	20	38	337	417	450	2000	35	25
$\bar{n}$	0.05	0.10	0.20	0.20	0.05	0.05	0.05	0.05	0.10	0.15
SLOPE (ft/mi)	69.89	14.53	10.99	21.35	117.02	114.57	103.45	177.94	18.92	11.47
LLca/S**.5	0.73	0.23	0.55	0.38	0.45	0.77	0.85	4.33	0.38	0.67
Lag (hours)	1.07	1.37	3.84	3.33	0.89	1.09	1.13	2.10	1.67	3.11
S-Curve	(1)	(2)	(2)	(2)	(1)	(1)	(1)	(1)	(2)	(2)
TIME PERIOD (hours)	One hour unit hydrograph ordinates (end of period flows in c.f.s.)									
1	1786	108	6	20	698	576	803	1540	74	19
2	1513	205	20	76	377	514	794	4720	234	73
3	425	60	46	170	101	145	225	3468	88	152
4	179	30	58	129	35	62	98	1546	41	94
5	67	19	32	68	3	24	42	854	25	49
6	5	12	19	43		3	7	545	17	32
7		9	14	30				355	12	22
8		6	10	23				226	9	17
9		3	8	18				141	7	13
10		1	6	14				65	5	11
11			5	12				10	3	9
12			4	10					1	7
13			4	8						6
14			3	7						5
15			3	6						5
16			2	5						4
17			2	5						3
18			2	4						3
19			2	3						2
20			1	3						2
21			1	2						1
22			1	1						1
23			1	1						
24			1	1						
25			1							
TOTAL	3975	453	252	659	1214	1324	1969	13470	516	530

Notes:
(1) Fresno Redbank-Fancher Mountain S-Curve.
(2) L.A. Valley S-Curve.

TABLE H-11 (Continued)

STANDARD PROJECT AND 200-YEAR FLOODS
UNIT HYDROGRAPH CHARACTERISTICS
AND ORDINATES FOR
DRY, REDBANK, FANCHER CREEKS AND CANAL SYSTEMS

	FANCHER CREEK	REDBANK CREEK								
SUBAREAS	233430	222840	222730	223410	223530	230940	231030	231610	231510	231640
CHARACTERISTICS										
D.A. (sq. mi.)	0.36	0.78	0.86	1.13	0.20	5.12	0.44	0.30	1.04	0.29
L (mi.)	1.81	2.37	2.24	1.71	0.72	2.35	1.61	1.02	2.46	1.02
Lca (mi.)	1.15	1.14	1.14	0.83	0.42	1.14	0.76	0.51	0.95	0.51
Delta H. (ft)	25	70	155	155	450	45	40	10	50	10
$\bar{n}$	0.15	0.05	0.05	0.05	0.05	0.04	0.04	0.10	0.10	0.10
SLOPE (ft/mi)	13.82	29.54	69.20	90.65	625.01	19.15	24.85	9.81	20.33	9.81
LLca/S**.5	0.57	0.50	0.31	0.15	0.02	0.62	0.25	0.17	0.52	0.17
Lag (hours)	2.90	0.93	0.78	0.60	0.26	0.80	0.57	1.24	1.88	1.24
S-Curve	(2)	(1)	(1)	(1)	(1)	(2)	(1)	(2)	(2)	(2)
TIME PERIOD (hours)	One hour unit hydrograph ordinates (end of period flows in c.f.s.)									
1	9	275	369	519	127	2045	229	61	71	59
2	39	165	141	165	2	784	47	81	283	78
3	70	45	37	41		262	8	23	133	22
4	37	16	8	5		129		12	61	11
5	20	3				65		7	37	7
6	13					19		5	25	5
7	9							3	18	3
8	7							2	13	2
9	6							1	10	1
10	5								8	
11	4								6	
12	3								4	
13	3								2	
14	2								1	
15	2									
16	2									
17	1									
18	1									
19	1									
20										
21										
22										
23										
24										
25										
TOTAL	234	504	555	730	129	3304	284	195	672	188

TABLE H-11 (Continued)

STANDARD PROJECT AND 200-YEAR FLOODS
UNIT HYDROGRAPH CHARACTERISTICS
AND ORDINATES FOR
DRY, REDBANK, FANCHER CREEKS AND CANAL SYSTEMS

	REDBANK CREEK				DOG CREEK					
SUBAREAS	231940	230840	231930	132640	212140	222820	130720	230710	230820	132430
CHARACTERISTICS										
D.A. (sq. mi.)	1.21	1.17	1.74	0.83	14.90	0.84	1.84	0.53	3.55	0.81
L (mi.)	3.64	2.92	2.99	2.24	10.38	1.71	4.24	0.83	3.22	2.54
Lca (mi.)	1.82	1.18	1.52	1.17	6.06	0.64	2.46	0.30	1.48	1.25
Delta H. (ft.)	50	52	85	20	1925	40	80	25	65	30
$\bar{n}$	0.10	0.10	0.15	0.10	0.05	0.05	0.10	0.10	0.10	0.15
SLOPE (ft/mi)	13.74	17.81	28.43	8.93	185.46	23.40	18.87	30.13	20.19	11.82
LLca/S**.5	1.79	0.82	0.86	0.88	4.62	0.23	2.40	0.05	1.07	0.93
Lag (hours)	3.00	2.23	3.40	2.29	2.15	0.69	3.35	0.78	2.46	3.51
S-Curve	(2)	(2)	(2)	(2)	(1)	(1)	(2)	(2)	(2)	(2)
TIME PERIOD (hours)	One hour unit hydrograph ordinates (end of period flows in c.f.s.)									
1	30	54	33	36	1059	394	36	217	130	15
2	119	247	122	166	3224	117	133	79	593	53
3	233	194	279	143	2523	29	302	26	668	121
4	128	84	227	61	1158	3	236	13	287	111
5	70	48	119	35	633		124	6	164	57
6	45	32	76	24	403		79	1	108	36
7	32	24	52	17	265		54		78	25
8	24	18	39	13	172		41		60	19
9	19	14	31	10	108		32		47	15
10	16	11	25	8	57		26		37	12
11	13	9	21	7	13		22		30	10
12	10	7	17	5			18		25	8
13	9	5	15	4			15		20	7
14	8	4	12	3			13		16	6
15	6	2	11	2			11		12	5
16	5	1	9	1			10		8	5
17	4		8	1			8		5	4
18	4		7				7		3	3
19	3		6				6			3
20	2		5				5			2
21	1		4				4			2
22	1		3				3			2
23			2				2			1
24			1				1			1
25			1							1
TOTAL	782	754	1125	536	9615	543	1188	342	2291	524

TABLE H-11 (Continued)

STANDARD PROJECT AND 200-YEAR FLOODS
UNIT HYDROGRAPH CHARACTERISTICS
AND ORDINATES FOR
DRY, REDBANK, FANCHER CREEKS AND CANAL SYSTEMS

	DOG CREEK	DRY CREEK								
SUBAREAS	132440	221530	222030	222020	221810	220730	121230	121130	122220	122221
CHARACTERISTICS										
D.A. (sq. mi.)	2.49	44.00	5.60	1.46	0.38	7.77	0.54	0.70	3.30	3.03
L (mi.)	3.07	20.00	4.95	1.74	1.00	5.23	1.21	1.86	1.90	WATER
Lca (mi.)	1.90	10.00	2.62	0.64	0.32	2.39	0.49	0.91	0.80	SURFACE
Delta H. (ft)	30	4090	325	115	138	472	565	765	30	AREA
$\bar{n}$	0.15	0.08	0.07	0.05	0.05	0.05	0.05	0.05	0.04	
SLOPE (ft/mi)	9.78	204.51	65.66	66.10	138.01	90.25	466.95	411.30	15.79	
LLca/S**.5	1.87	13.99	1.61	0.14	0.03	1.32	0.03	0.09	0.39	
Lag (hours)	4.57	5.24	2.02	0.58	0.33	1.34	0.33	0.48	0.68	0.00
S-Curve	(2)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(2)	
TIME PERIOD (hours)	One hour unit hydrograph ordinates (end of period flows in c.f.s.)									
1	27	725	443	758	233	1485	331	390	1485	1955
2	82	1573	1347	158	12	2255	17	58	419	
3	184	2682	900	26		699		4	142	
4	318	3825	385			321			64	
5	267	4437	216			163			19	
6	159	3498	138			76			1	
7	106	2701	88			14				
8	78	1977	54							
9	59	1359	33							
10	46	1010	11							
11	39	826								
12	32	679								
13	27	569								
14	24	474								
15	21	393								
16	18	337								
17	16	288								
18	14	240								
19	13	194								
20	11	160								
21	10	135								
22	9	117								
23	8	86								
24	7	56								
25	6	36								
26	6	19								
27	[illegible]									
28	4									
29	3									
30	3									
31	2									
32	1									
33	1									
TOTAL	1606	28396	3615	942	245	5013	348	452	2130	1955

TABLE H-11 (Continued)

STANDARD PROJECT AND 200-YEAR FLOODS
UNIT HYDROGRAPH CHARACTERISTICS
AND ORDINATES FOR
DRY, REDBANK, FANCHER CREEKS AND CANAL SYSTEMS

	LITTLE DRY CREEK DIVERSION CHANNEL LOCAL					DRY CR LOCAL	ALLUVIAL DRAIN	PUP CREEK		
SUBAREAS	121120	120340	120330	120320	120920	122810	122730	223030	123530	130120
CHARACTERISTICS										
D.A. (sq. mi.)	0.11	1.41	0.16	0.33	2.76	0.60	2.65	0.49	1.06	1.12
L (mi.)	0.45	2.05	0.45	0.95	3.18	2.39	2.98	1.63	2.27	2.30
Lca (mi.)	0.30	1.10	0.23	0.32	1.33	1.50	1.10	0.85	1.02	0.87
Delta H. (ft)	125	905	145	304	70	15	57	45	43	48
$\bar{n}$	0.05	0.05	0.05	0.05	0.05	0.10	0.15	0.15	0.15	0.15
SLOPE (ft/mi)	277.78	441.47	322.23	320.01	22.02	6.28	19.13	27.61	18.95	20.87
LLca/S**.5	0.01	0.11	0.01	0.02	0.91	1.43	0.75	0.27	0.54	0.44
Lag (hours)	0.24	0.53	0.22	0.29	1.16	2.76	3.24	2.19	2.85	2.65
S-Curve	(1)	(1)	(1)	(1)	(2)	(2)	(2)	(2)	(2)	(2)
TIME PERIOD (hours)	One hour unit hydrograph ordinates (end of period flows in c.f.s.)									
1	71	760	102	207	652	17	56	24	28	34
2	1	135	1	6	690	74	209	107	120	153
3		15			199	119	462	80	208	224
4					102	57	325	34	105	99
5					61	32	169	20	58	56
6					40	20	109	13	37	36
7					24	15	75	10	27	26
8					12	11	57	7	20	20
9					2	9	45	6	16	16
10						7	37	5	13	13
11						6	30	4	11	10
12						5	25	3	9	9
13						4	21	2	7	7
14						3	18	2	6	6
15						3	15	1	5	5
16						2	13		4	4
17						2	11		3	3
18						1	9		3	2
19						1	8		2	1
20							6		1	
21							5		1	
22							3			
23							2			
24							1			
25										
26										
TOTAL	72	910	103	213	1782	388	1711	318	684	724

TABLE H-11 (Continued)

STANDARD PROJECT AND 200-YEAR FLOODS
UNIT HYDROGRAPH CHARACTERISTICS
AND ORDINATES FOR
DRY, REDBANK, FANCHER CREEKS AND CANAL SYSTEMS

	PUP CREEK		ENTERPRISE CANAL					GOULD CANAL		
SUBAREAS	130130	130230	332020	231820	231331	231430	123531	232630	232710	232910
CHARACTERISTICS										
D.A. (sq. mi.)	0.54	1.05	1.00	0.47	0.82	0.50	2.00	2.38	1.57	2.93
L (mi.)	0.72	1.59	4.36	0.78	1.07	1.14	3.71	2.59	1.86	2.92
Lca (mi.)	0.38	0.95	2.18	0.37	0.37	0.38	1.85	1.59	0.99	1.52
Delta H. (ft)	10	25	30	25	30	27	60	25	28	32
$\bar{n}$	0.15	0.15	0.05	0.10	0.10	0.10	0.10	0.15	0.15	0.15
SLOPE (ft/mi)	13.89	15.73	6.89	32.06	28.04	23.69	16.18	9.66	15.06	10.96
LLca/S**.5	0.08	0.39	3.62	0.06	0.08	0.09	1.71	1.33	0.48	1.34
Lag (hours)	1.38	2.51	1.96	0.81	0.93	0.99	2.95	4.02	2.73	4.03
S-Curve	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
TIME PERIOD (hours)	One hour unit hydrograph ordinates (end of period flows in c.f.s.)									
1	82	37	61	186	284	161	50	32	45	39
2	158	166	263	73	150	99	207	105	199	128
3	47	201	135	24	48	31	389	251	312	305
4	23	87	62	12	24	16	206	358	146	438
5	14	50	36	6	14	9	113	207	82	257
6	9	33	25	2	7	5	74	125	53	155
7	7	23	18		2	2	52	87	38	108
8	4	18	13			1	39	64	29	79
9	3	14	10				31	49	23	61
10	1	11	8				25	39	18	49
11		9	6				21	33	15	40
12		8	4				17	28	12	34
13		6	3				14	24	10	29
14		5	1				12	20	9	25
15		4					10	18	7	22
16		3					8	15	6	19
17		2					7	13	4	17
18		1					6	12	3	15
19							4	10	2	13
20							3	9	1	11
21							2	8		10
22							1	7		9
23								6		7
24								5		6
25								4		5
26								3		4
27								2		3
28								2		2
29								1		1
30										1
TOTAL	348	678	645	303	529	324	1291	1537	1014	1892

TABLE H-11 (Continued)

STANDARD PROJECT AND 200-YEAR FLOODS
UNIT HYDROGRAPH CHARACTERISTICS
AND ORDINATES FOR
DRY, REDBANK, FANCHER CREEKS AND CANAL SYSTEMS

	GOULD CANAL			FRESNO CANAL		
SUBAREAS	233010	332710	332730	233431	233110	132530
CHARACTERISTICS						
D.A. (sq.mi)	0.78	1.34	1.02	0.99	2.95	1.95
L (mi.)	2.20	1.90	1.48	2.18	3.22	2.65
Lca (mi.)	1.02	0.70	0.99	1.30	1.78	1.14
Delta H. (ft)	25	225	235	13	30	25
$\bar{n}$	0.15	0.05	0.05	0.20	0.20	0.20
SLOPE (ft/mi)	11.37	118.43	158.79	5.97	9.32	9.44
LLca/S**.5	0.67	0.13	0.12	1.16	1.88	0.99
Lag (hours)	3.10	0.55	0.54	5.09	6.11	4.78
S-Curve	(2)	(1)	(1)	(2)	(2)	(2)
TIME PERIOD (hours)	One hour unit hydrograph ordinates (end of period flows in c.f.s.)					
1	18	708	543	9	20	20
2	70	138	103	24	50	57
3	145	19	12	55	95	125
4	89			96	180	227
5	47			117	270	222
6	30			75	287	134
7	21			49	194	86
8	16			34	131	64
9	13			27	98	50
10	10			21	77	37
11	8			17	62	32
12	7			14	51	26
13	6			12	42	23
14	5			10	37	20
15	4			9	32	17
16	4			8	28	15
17	3			7	25	13
18	3			6	23	12
19	2			6	20	10
20	2			5	19	9
21	1			5	16	9
22	1			4	15	8
23				4	14	7
24				3	12	6
25				3	11	6
26				3	11	5
27				3	10	4
28				2	9	4
29				2	8	3
30				2	8	3
31				2	7	2
32				1	6	2
33				1	6	1
34				1	5	1
35				1	5	1
36				1	4	
37					4	
38					3	
39					3	
40					2	
41					2	
42					2	
43					1	
44					1	
45					1	
46					1	
47					1	
48					1	
49					1	
50					1	
51					1	
52					1	
53					1	
54					1	
TOTAL	505	865	658	639	1916	1261

HYDROLOGY APPENDIX
TABLE H-12

PROBABLE MAXIMUM FLOOD
UNIT HYDROGRAPH CHARACTERISTICS
AND ORDINATES FOR
DRY AND FANCHER CREEKS ABOVE THEIR RESERVOIRS

	DOG CREEK	DRY CREEK								
SUBAREAS	212140	221530	222030	222020	221810	220730	121230	121130	122220	122221
CHARACTERISTICS										
D.A. (sq.mi)	14.90	44.00	5.60	1.46	0.38	7.77	0.54	0.70	3.30	3.03
L (mi.)	10.38	20.00	4.95	1.74	1.00	5.23	1.21	1.86	1.90	WATER
Lca (mi.)	6.06	10.00	2.62	0.64	0.32	2.39	0.49	0.91	0.80	SURFACE
Delta H. (ft)	1925	4090	325	115	138	472	565	765	30	AREA
$\overline{n}$	0.040	0.055	0.056	0.040	0.040	0.040	0.040	0.040	0.032	
SLOPE (ft/mi)	185.46	204.51	65.66	66.10	138.01	90.25	466.95	411.30	15.79	
LLca/S**.5	4.62	13.99	1.61	0.14	0.03	1.32	0.03	0.09	0.30	
Lag (hours)	1.72	3.60	1.61	0.46	0.27	1.07	0.27	0.39	0.54	0
S-Curve	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(2)	
TIME PERIOD (hours)	One hour unit hydrograph ordinates (end of period flows in c.f.s.)									
1	1736	1250	750	824	241	2248	342	415	1654	1955
2	4021	3385	1581	113	4	1912	6	36	335	
3	1999	5773	662	5		537		1	110	
4	840	5717	297			227			31	
5	480	3907	163			85				
6	284	2367	94			6				
7	161	1564	50							
8	82	1114	17							
9	13	823								
10		654								
11		508								
12		397								
13		308								
14		230								
15		181								
16		127								
17		64								
18		26								
TOTAL	9616	28395	3614	942	245	5015	348	452	2130	1955

Notes:
(1) Fresno Redbank-Fancher Mountain S-Curve.
(2) L.A. Valley S-Curve.

HYDROLOGY APPENDIX
TABLE H-12 (Continued)

PROBABLE MAXIMUM FLOOD
UNIT HYDROGRAPH CHARACTERISTICS
AND ORDINATES FOR
DRY AND FANCHER CREEKS ABOVE THEIR RESERVOIRS

	LITTLE DRY CREEK DIVERSION CHANNEL LOCAL					FANCHER CREEK			
SUBAREAS	121120	120340	120330	120320	120920	222640	223540	230210	231220
CHARACTERISTICS									
D.A. (sq.mi)	0.11	1.41	0.16	0.33	2.76	1.88	2.05	3.05	20.87
L (mi.)	0.45	2.05	0.45	0.95	3.18	2.88	3.64	4.35	11.24
Lca (mi.)	0.30	1.10	0.23	0.32	1.33	1.67	2.24	1.97	5.13
Delta H. (ft)	125	905	145	304	70	337	417	450	2000
$\overline{n}$	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
SLOPE (ft/mi)	277.78	441.47	322.23	320.01	22.02	117.02	114.57	103.45	177.94
LLca/S**.5	0.01	0.11	0.01	0.02	0.91	0.45	0.77	0.85	4.33
Lag (hours)	0.19	0.42	0.18	0.23	0.93	0.71	0.87	0.91	1.68
	(1)	(1)	(1)	(1)	(2)	(1)	(1)	(1)	(1)
TIME PERIOD (hours)	One hour unit hydrograph ordinates (end of period flows in c.f.s.)								
1	72	817	103	212	953	862	780	1109	2569
2		92		1	508	275	399	626	5740
3		1			161	68	107	167	2666
4					82	8	35	60	1151
5					47		3	7	653
6					24				375
7					7				214
8									93
9									10
10									
11									
12									
13									
14									
15									
16									
17									
18									
TOTAL	72	910	103	213	1782	1213	1324	1969	13471

21. Flow Frequency Curves. - Feasibility Report flow frequency curves for the Big Dry Creek Reservoir and Dry Creek at Academy were updated with twelve additional years of record. The old record spanned the years 1949 through 1978. The new flow frequency curves reflect the water years 1942 through 1983. The procedures used to develop the peak flow frequency curves generally follow the Water Resources Council's, "Guidelines For Determining Flood Flow Frequency," revised in September 1981. Procedures used in determining the volume frequency curves are found in HEC-IHD-0300, "Hydrologic Engineering Methods for Water Resources Development, Volume 3, Hydrologic Frequency Analysis," published April 1975.

Other foothill streamflow records in the area were examined to determine regional variation in means, standard deviation and skews. The foothill stream gauges located outside the project area which were analyzed are tabulated below:

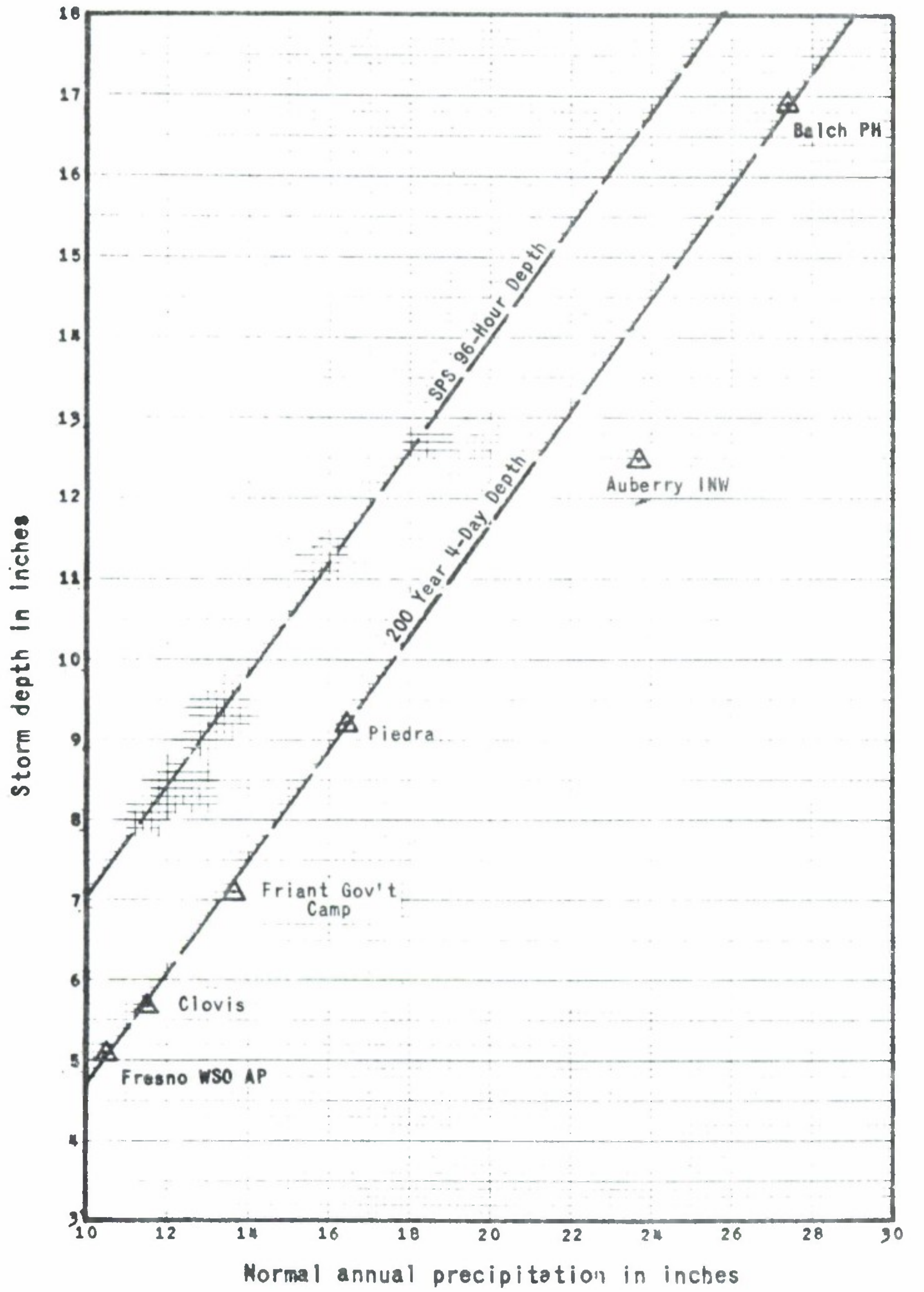
Station	Drainage Area (sq. mi.)	Years of Record	Normal Annual Precipitation (inches)
Fresno River near Knowles	133	66	32.2
Mill Creek near Piedra	127	45	24.6
Dry Creek near Lemon Cove	75.6	22	23.4
Sand Creek near Orange Cove	31.6	20	18.3

This analysis was made primarily for the purpose of developing the duration flow frequency curves. There were too few stations and too great a variation in the statistics to construct any type of isoline patterns for the standard deviation and skew. The means were generally influenced by normal annual precipitation. The standard deviations increased as the influence of snowmelt and the normal annual precipitation decreased. The standard deviations ranged from 0.464 (1-day) to 0.369 (30-day) on the Fresno River near Knowles, to 0.814 (1-day) to 0.700 (30-day) for Dry Creek near Lemon Cove. The skews were negative for all the shorter durations and approached a skew of zero for the Dry Creek at Academy and the Sand Creek near Orange Cove gauges for the 30-day curves. These statistical data provided a range of values that were used to evaluate the synthetic flow frequency curves prepared for Fancher Creek Reservoir.

Frequency curves for Fancher Creek Reservoir inflow were developed from relationships developed from the frequency curves on Dry Creek and synthetic floods developed for Fancher Creek Reservoir.

The frequency curves for Big Dry Creek at Academy, Big Dry Creek Reservoir Inflow, and Fancher Creek Reservoir are shown on Figures H-6, H-7 and H-8. The corresponding statistics are shown in Table H-15 below.

A comparison of the updated peak flow frequency curves with those in the Feasibility Report, shows no significant change between the two. However, the longer volume duration curves did change. The 7 through 30-day 200-year volumes decreased; the data showed a lower mean and smaller standard deviation. The updated volume duration curves for Big Dry Creek Reservoir and Fancher Creek Reservoir resulted in smaller required storage space to control their respective project floods.



LEGEND:

△ 200-year 4-day storm depths in inches.

REDBANK AND FANCHER CREEKS
CALIFORNIA

STANDARD PROJECT AND 200-YR.
STORM DEPTH CURVES

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: R.F.C.
Drawn: C.A.P.
Date:

FIGURE H-5

Table H-13

Storm Amounts and Loss Rates

Outflow Channel Drainage Area	Subarea Number	D.A. (sq.mi)	NAP (in.)	PMP (in.)	SPS (in.)	200-YR Storm (in.)	Loss Rate (in/hr)	Imperv. Area %
Dog Cr to Dry Cr	212140	14.90	18.17	23.83	12.72		0.10	0.0
Dry Creek	220730	7.77	13.50	14.38	8.78		0.10	0.0
	221530	44.00	19.70	23.83	12.72		0.10	0.0
	222020	1.46	12.80	15.49	8.32		0.10	0.0
	222030	5.60	13.50	14.30	8.78		0.13	0.0
	122810	0.60	12.70	15.38	8.26		0.15	0.0
	121130	0.70	12.80	15.49	8.32		0.10	0.0
	121230	0.54	12.80	15.49	8.32		0.10	0.0
	122220	3.30	12.70	15.38	8.25		0.10	0.0
	122221	3.03	12.70	15.38	8.26		0.00	0.0
	221810	0.38	12.70	15.49	8.32		0.15	0.0
Little Dry Creek Diversion Channel	120320	0.33	12.80		8.32		0.08	0.0
	120330	0.16	12.80		8.32		0.08	0.0
	120340	1.14	12.80		8.32		0.08	0.0
	120920	2.76	12.70		8.26		0.10	0.0
	121120	0.11	12.80		8.32		0.08	0.0
Fancher Creek	222640	1.88	13.50	18.68		7.17	0.10	0.0
	223540	2.05	13.50	18.68		7.17	0.10	0.0
	230210	3.05	13.50	18.68		7.17	0.10	0.0
	231220	20.87	15.90	22.00		8.82	0.11	0.0
	231330	0.80	12.60	17.43		6.56	0.10	7.4
	232620	0.82	12.05	16.67		6.18	0.15	1.0
	233430	0.36	11.55	15.90		5.83	0.20	2.3
Alluvial Drain	122730	2.65	12.70			6.62	0.10	0.0
Enterprise Canal	123531	2.00	12.00			6.14	0.15	0.0
	231331	0.82	12.60			6.56	0.07	1.3
	231430	0.50	12.42			6.43	0.20	7.0
	231820	0.47	12.75			6.66	0.07	1.3
	332020	1.00	12.40			6.42	0.10	0.0
	332710	1.34	13.50			7.17	0.10	0.0
	332730	1.02	13.50			7.17	0.20	0.0
Fresno Canal	233110	2.95	11.72	5.95	0.20	1.6		
	233431	0.99	11.72	5.95	0.20	0.2		
Gould Canal	232541	1.02	12.40	6.42	0.20	0.2		
	232630	2.38	12.14	6.24	0.10	0.0		
	232710	1.57	11.72	5.59	0.20	4.9		
	232910	2.93	11.72	5.95	0.20	3.3		

Table H-13 (Continued)

Storm Amounts and Loss Rates

Outflow Channel Drainage Area	Subarea Number	D.A.	NAP	200-Yr Storm	Const. Loss	Imperv. Area
	(sq.mi)	(in.)	(in.)	(in.)	(in.)	(in/hr) %
Gould Canal (cont'd)	233010	0.78	11.72	5.95	0.20	0.4
Mill Ditch	132530	1.95	11.72	5.95	0.20	0.0
Mud Creek	232540	0.39	12.40	6.42	0.15	0.0
	331730	6.16	13.50	7.17	0.11	0.0
	331920	0.70	12.75	6.66	0.07	0.0
Pup Creek	123530	1.06	12.00	6.14	0.10	2.8
	130120	1.12	12.00	6.14	0.16	3.8
	130130	0.54	12.00	6.14	0.16	0.0
	130230	1.05	11.50	5.80	0.10	3.3
	223030	0.49	13.20	6.97	0.10	1.7
Dog Creek To Redbank Creek	130720	1.84	12.18	6.27	0.19	2.2
	132430	0.81	11.18	5.58	0.14	0.0
	132440	2.49	11.18	5.58	0.15	0.0
	222820	0.84	12.93	6.78	0.10	0.0
	230710	0.53	12.14	6.24	0.12	9.7
	230820	3.55	12.14	6.24	0.12	0.0
Redbank Creek	132640	0.83	12.05	6.18	0.20	0.0
	222730	0.86	13.50	7.17	0.07	0.0
	222840	0.78	13.50	7.17	0.07	0.0
	223410	1.13	13.50	7.17	0.07	0.0
	223530	0.20	13.50	7.17	0.07	0.0
	230840	1.17	12.14	6.24	0.12	7.5
	230940	5.12	12.60	6.56	0.07	1.9
	231030	0.44	12.42	6.43	0.07	4.0
	231510	1.04	12.42	6.43	0.07	2.8
	231610	0.30	11.50	5.80	0.14	1.7
	231640	0.29	11.50	5.80	0.14	0.6
	231940	1.21	11.50	5.80	0.14	0.1
	321930	1.74	11.34	5.69	0.14	1.1

Table H-14

Standard Project and 200-Year 96-Hour Precipitation
Distribution as the Ratios of the 96-Hour Precipitation Depth
Over the Area

Time Hour	SPS Ratio	200 Year Ratio	Time Hour	SPS Ratio	200 Year Ratio	Time Hour	SPS Ratio	200 Year Ratio
1	.000	.000	33	.007	.007	65	.034	.034
2	.000	.000	34	.008	.008	66	.032	.032
3	.000	.000	35	.009	.009	67	.024	.026
4	.000	.000	36	.009	.009	68	.022	.025
5	.000	.000	37	.009	.009	69	.019	.024
6	.000	.000	38	.009	.009	70	.018	.015
7	.001	.002	39	.009	.009	71	.017	.015
8	.002	.002	40	.011	.011	72	.016	.015
9	.002	.002	41	.011	.011	73	.014	.024
10	.003	.000	42	.012	.022	74	.012	.022
11	.002	.002	43	.012	.014	75	.010	.013
12	.002	.002	44	.012	.012	76	.010	.010
13	.003	.003	45	.013	.013	77	.009	.009
14	.003	.002	46	.012	.022	78	.009	.009
15	.003	.002	47	.013	.023	79	.006	.006
16	.003	.003	48	.014	.024	80	.005	.005
17	.004	.004	49	.015	.003	81	.005	.005
18	.003	.003	50	.015	.015	82	.005	.004
19	.003	.003	51	.016	.016	83	.004	.003
20	.004	.001	52	.016	.016	84	.004	.002
21	.004	.004	53	.017	.017	85	.003	.000
22	.005	.005	54	.019	.019	86	.002	.000
23	.005	.005	55	.020	.015	87	.002	.000
24	.006	.006	56	.021	.009	88	.002	.000
25	.005	.005	57	.023	.025	89	.001	.000
26	.005	.005	58	.026	.026	90	.001	.000
27	.005	.005	59	.028	.028	91	.000	.000
28	.006	.006	60	.032	.032	92	.000	.000
29	.007	.007	61	.036	.036	93	.000	.000
30	.007	.007	62	.040	.040	94	.000	.000
31	.006	.006	63	.076	.070	95	.000	.000
32	.007	.007	64	.038	.038	96	.000	.000

Peak flow curves for Alluvial Drain, Pup Creek, and Redbank Creek Detention Basins at or just below the detention basins did not change.

22. Project Floods. - A thirty-day, six-wave, Standard Project Flood and a 200-year flood series were developed for Dry Creek and Fancher Creek reservoirs, respectively. The main five-day wave was computed by using the 96-hour project storm and the HEC-1 basin model developed to analyze project conditions. The remaining five waves were developed using ratios of the main wave. These ratios were obtained from volume duration flow frequency curves developed for the Dry Creek at Academy gauge.

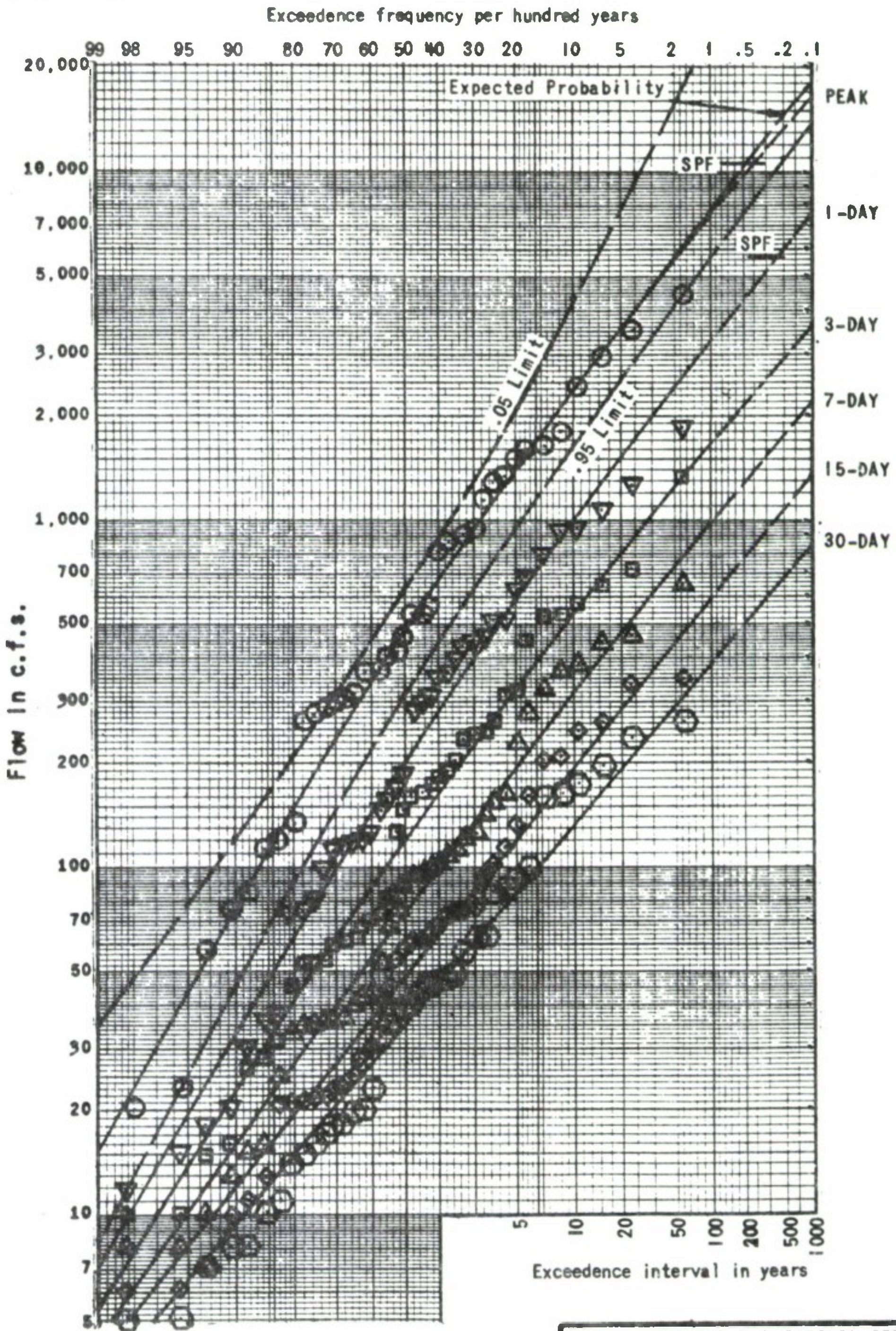
The ratios of the six 5-day waves to the main wave for the Standard Project Flood for Big Dry Creek Reservoir are .130, .203, .387, 1.000, .219, and .136. The ratios of the six 5-day waves to the main wave for the 200-year flood for Redbank and Fancher Creeks are .143, .221, .513, 1.000, .239, and .148. The 30-day series hydrographs are shown on Fiqures H-8 through H-15.

23. Basin Computer Model. - The computer program HEC-1 "Flood Hydrograph Package" was used to model the complex runoff conditions of the study area for the Feasibility Report. The HEC-1 basin model was updated for the GDM studies by adding new subareas, and updating other subareas and routing criteria to adequately reflect the interrelationship of creeks and canals during the SPF and 200 year floods. Specifically, the revised basin model includes: a) integration of Mud Creek Basin as a new subarea, b) addition of Enterprise and Gould Canals, c) development of routing parameters for all areas above Friant-Kern Canal in the Dry Creek Basin, d) development of routing parameters for all project related canals, and e) integration of streams and canals in the project area into a homogeneous system consisting of streams (Mud Creek, Fancher Creek, Redbank Creek, Dog Creek, Pup Creek, Dry Creek, and Alluvial Drain), canals (Friant-Kern Canal, Enterprise Canal, Gould Canal, Fresno Canal, Mill Ditch and Herndon Canal), and structures (Dog Creek Diversion to Dry Creek, Dry Creek Reservoir, Little Dry Creek Diversion, private and public reservoirs on Redbank and Pup Creeks, Redbank Reservoir, canal levees, canal diversions, culverts and siphons).

In addition to the above changes, project design precipitation, unit hydrograph, and loss rate data were incorporated into the basin computer model.

The following criteria and assumptions were made when running the HEC-1 basin model to provide data needed to size the project features.

a) Routing Methods. - Two routing methods (the Muskingum and Modified Puls) are used to convey water through hydraulic constrictions, streams, canals, and overland areas. The Muskingum routing method is used for canals with little variance in cross-sectional area and velocity (Storage - discharge relationship is linear). The Modified Puls routing method is used for streams, canals, and overbank flood areas with great variability in cross-sectional area and velocity (the storage-flow relationship is



LEGEND:

- ⊙ Peak.
- ▼ 1-Day.
- ◘ 3-Day.
- ▲ 7-Day.
- ◇ 15-Day.
- ⬡ 30-Day.

NOTES:

20 years of record. (1942-1963)
Lower value points were not plotted.
Drainage area: 88.0 sq. mi.

REDBANK AND FANCHER CREEKS
CALIFORNIA

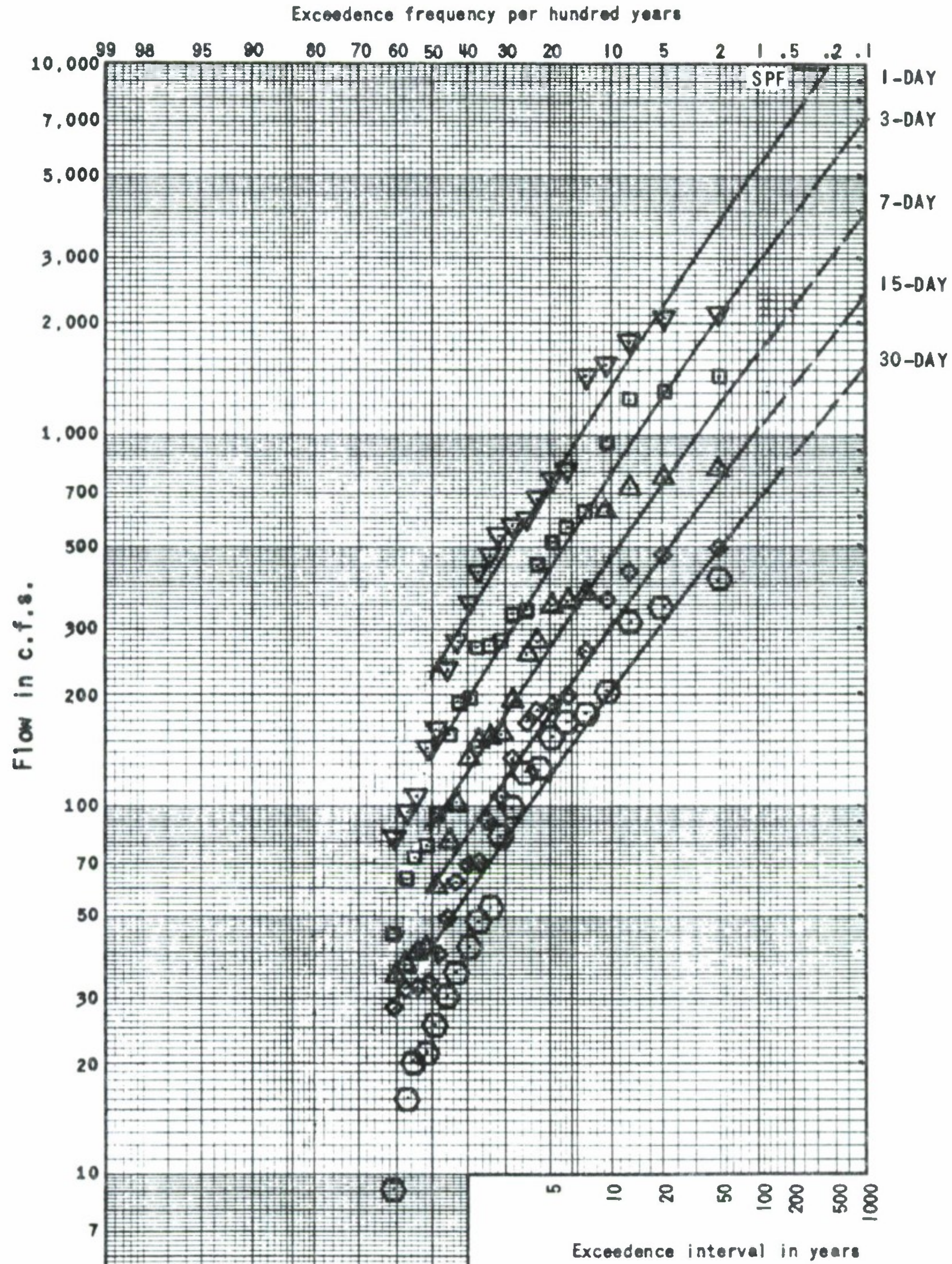
FLOW FREQUENCY CURVES

DRY CREEK NEAR ACADEMY

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: B.F.C. Date:
Drawn: C.A.P.

FIGURE H-6



LEGEND:

- ▽ 1-Day.
- ⊡ 3-Day.
- △ 7-Day.
- ◇ 15-Day.
- ⬡ 30-Day.

NOTES:

34 years of record. (1950-1983)

Lower value points were not plotted.

Drainage area: 81.7 sq. mi.

REDBANK AND FANCHER CREEKS
CALIFORNIA

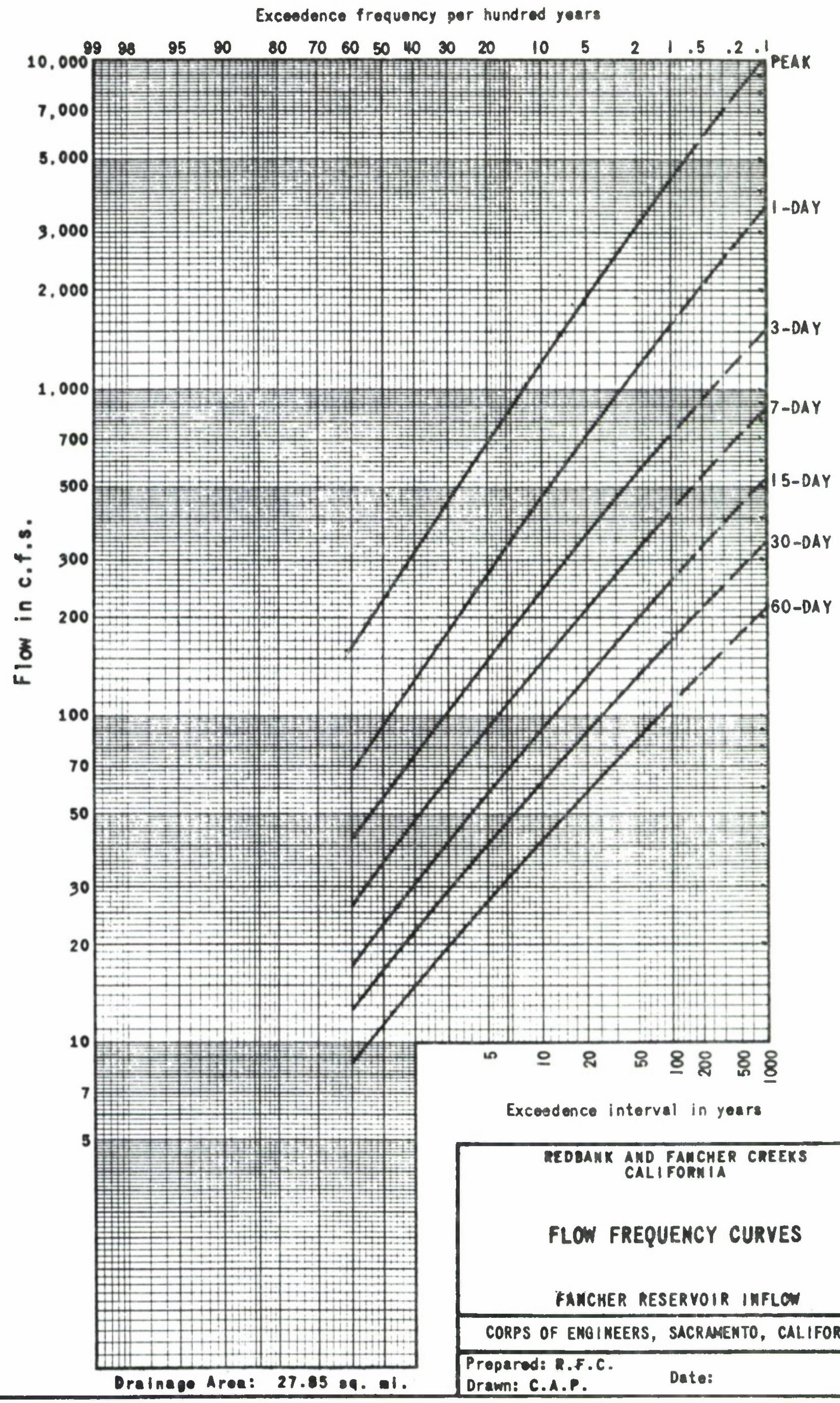
FLOW FREQUENCY CURVES

BIG DRY CREEK RESERVOIR INFLOW

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: R.F.C.
Drawn: C.A.P.
Date:

FIGURE H-7



REDBANK AND FANCHER CREEKS
CALIFORNIA

FLOW FREQUENCY CURVES

FANCHER RESERVOIR INFLOW

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: R.F.C.
Drawn: C.A.P.
Date:

FIGURE H-8

Table H-15

Peak and Volume Statistics for
Project Frequency Curves

Location	Peak	1-Day	3-Day	7-Day	15-Day	30-Day
Dry Creek at Academy						
Mean	2.652	2.276	2.062	1.86	1.683	1.550
Standard Deviation	.585	.573	.535	.503	.471	.449
Skew	-.30	-.20	-.20	-.10	0.0	0.0
Big Dry Creek Reservoir Inflow						
Mean	N/A	2.326	2.114	1.929	1.760	1.602
Standard Deviation	N/A	.640	.620	.592	.576	.562
Skew	N/A	-.20	-.20	-.20	-.20	-.20
Fancher Creek Reservoir Inflow						
Mean	2.330	1.952	1.735	1.532	1.342	1.041
Standard Deviation	.600	.573	.514	.501	.493	.461
Skew	-.20	-.20	-.20	-.20	-.20	-.20

nonlinear). Muskingum and Modified Puls data are shown in Tables H-16 and H-17.

The majority of the storage-discharge data used in the Modified Puls routings were gleaned from the Fresno Flood Insurance Study (conducted in 1979). In areas where storage-discharge data were not available, they were developed from field surveys and hydraulic analysis.

(b) Flood Flow Volumes. - No flood flow volumes from drainage areas above the Friant-Kern Canal that drain under or over the Friant-Kern Canal enter that canal.

(c) Canal Banks. - No canal bank in the study area fails when overtopped. Any excess flow over channel capacity spills out and travels crosscountry until it is intercepted by another channel.

(d) Canal Operations. - As soon as flood runoff starts to enter the canals, all flow from Holland Creek is diverted to the Kings River and all restrictions in the Gould and Enterprise Canals, such as boards and gates, are removed or opened fully to move water out of the system as rapidly as possible.

(e) Gould Canal. - No flow enters the Gould Canal from subareas above the Gould Enterprise Canal split. During the high flow periods inflow from Mud Creek and adjacent subareas causes overtopping of canal levees between Mud Creek and Redbank Creek. A diversion structure upstream of Fancher Creek (Vernon Ditch) diverts from 0-70 cfs to Fresno Canal when Gould Canal is flowing between 130 to 200 cfs. All flow in excess of the Gould Canal

capacity of 200 cfs is routed overland to Fresno Canal. A regulated siphon at Redbank Creek further controls flow in the canal to 150 cfs or less beyond Redbank Creek.

(f) Enterprise Canal. - As with the Gould Canal, Mud Creek and adjacent subarea flood flows can spill into the Enterprise Canal during high flow conditions. When the canal's capacity is exceeded at Mud Creek, the water spilling over the canal bank continues downstream in the Mud Creek Channel. Any excess flow spilling out of the Enterprise Canal between Mud Creek and Fancher Creek flows overland until it is intercepted by the Gould Canal.

Under project conditions, all the Enterprise Canal flows are diverted into Fancher Creek. This diversion is a local interest requirement for operating the flood control system. The flows that occur in the canal between Fancher and Redbank Creeks are from local runoff. Project flood flows do not exceed channel capacity in the reach from Fancher Creek to Dry Creek. The Enterprise Canal siphon under Dry Creek is set so that flows in excess of 90 cfs spill down Dry Creek to the Herndon Canal.

(g) Fresno Canal. - All flows entering the Fresno Canal remain in the Fresno Canal channel or the immediate overbank area and continue downstream to the Fancher Creek - Mill Ditch Diversion. It should be noted that "Fresno Canal" ends at this point and continues downstream as the Fancher Creek Canal (see Plate H1).

(h) Mill Ditch. - The headwork gates to Mill Ditch are shut off for the entire flood. For preproject flow the only flows entering Mill Ditch from the Fresno Canal are those in excess of 770 cfs. This is the estimated channel capacity of Fancher Creek Canal at the headworks. Any excess over the 770 cfs is divided in half, half spilling over the headworks into Mill Ditch and the remaining half continuing down Fancher Creek Canal. Under project conditions no flows enter Mill Ditch from the Fresno Canal. Flows in Mill Ditch combined with total outflows from the Redbank Flood Detention Basin are routed to the junction with Dry Creek and Herndon Canal. Total flows into Herndon Canal are estimated by combining all routed flows from Dry Creek, including flows from Enterprise and Gould Canals and Mill Ditch.

(i) Mud Creek. - Runoff from the Mud Creek basin is routed through restricting hydraulic structures at the Friant-Kern Canal and Enterprise Canal. Mud Creek enters the Gould Canal unrestricted. Runoff from Mud Creek during the project flood causes overtopping of the Gould Canal levees between Mud and Redbank Creeks. The excess runoff is routed overland to the Fresno Canal.

(j) Dog Creek. - All runoff originating above the diversion to Dry Creek is routed to Dry Creek. The remaining Dog Creek runoff below the diversion is routed to Redbank Creek and then to the Redbank Creek Detention Basin.

(k) Dry Creek Reservoir. - Hydrographs for all local areas located above the Friant-Kern Canal (that drain into the Reservoir area or contribute flow to the Little Dry Creek Diversion channel below the Reservoir) are routed over or under the Friant-Kern Canal before being combined. The Big Dry

inflow hydrograph is routed through the reservoir using the Modified Puls method, then combined with the local area contributing flows to the Little Dry Creek Diversion channel. All flow in excess of 700 cubic feet per second is diverted through a waste-way structure. For the SPF, no flows pass through the waste-way structure.

(1) Local Area Below Dry Creek Reservoir. - No flow releases are made from Big Dry Creek Reservoir during the project flood routings into either Dog Creek or Dry Creek. All local flow is routed into Dry Creek (downstream of Big Dry Creek Reservoir) and moved downstream to the project limits.

24. Big Dry Creek Reservoir Spillway Design Flood. - Spillway Design Flood (SDF) studies for Big Dry Creek were originally made in 1944 in conjunction with the preparation of a definite project report (DPR) on the flood control improvement. These studies used a 72-hour Probable Maximum Storm Precipitation (PMP) based on criteria from Hydrometeorological Report No. 3 ("Maximum Possible Precipitation over the Sacramento Basin," May 1942), which produced a depth of 13.0 inches of rain and 5.0 inches of water equivalent of antecedent snow cover. Ratios of normal annual precipitation were used to apply the Sacramento Basin PMP to the Big Dry-Dog Creeks areas. The resultant SDF had a peak flow of 17,000 cfs and a volume of 66,800 acre-feet. The SDF was subsequently revised and presented in a June 1973 office report ("Big Dry Creek Reservoir and Diversion, California, Hydrology"). The revised PMP amounts were obtained by methods and criteria presented in Hydrometeorological Report No. 36, "Probable Maximum Precipitation in California," October 1961 (and revisions of October 1969). The revised 72-hour PMP amount was 21.3 inches (it was assumed that a previous storm melted the snow), and the resultant PMF had a peak flow of 45,000 cfs and a volume of 66,800 acre-feet. In 1980, the Sacramento District completed a spillway adequacy study on Big Dry Creek Dam called "Big Dry Creek Dam and Diversion Probable Maximum Flood Study," dated July 1980. The results of this study agreed with the findings of the 1973 report. It is important to note these values assume that all the PMF flow from Big Dry and Dog Creeks enters the reservoir.

For the GDM study a PMF was calculated for Dry Creek and Dog Creek basins by use of the updated HEC-1 basin model. These PMF's were combined and routed into Big Dry Reservoir. PMF unit hydrographs and routing data used for this analysis are shown in Table H-12. The Dry Creek 1980 and current study showed the same results, i.e., a peak inflow of 45,000 cfs and volume of 66,800 acre-feet. The Dog Creek peak inflows (at the Dog Creek Diversion to Dry Creek) and 72-hour volumes differed slightly. Present study results show a peak of 12,000 cfs with a 72-hour volume of 13,800 acre-feet, compared to the previous study peak of 11,700 cfs and a 72-hour volume of 14,200 acre-feet (Dry Creek 1980).

25. Fancher Creek Dam Spillway Design Flood. - The PMP amounts developed for estimating the Fancher Creek Reservoir inflow were obtained by methods and criteria presented in Hydrometeorological Report HMR No. 36. Floods for both the 6-hour cloudburst from HMR 49 and the 72-hour general from HMR NQ 36 rain were computed. The 72-hour flood was used because it produced the more severe combination of peak and volume. Figure H-5 compares several PMF's

that were computed for other existing projects in California. The same methods used in the Feasibility Report were used in this report to derive the PMF. The present PMF inflow to Fancher Creek Reservoir has a peak of 20,600 cfs and and coicidently a volume of 20,600 acre-feet. The PMF for Fancher Creek in the Feasibility Report has a peak of 19,200 cfs with a volume of 17,600 acre-feet. The difference is caused by the increase in PMP amounts from an average of 18.2 inches to an average of 21.2 inches over the basin. All precipitation amounts used in this study are shown in Table H-13. A comparison of the PMF runoffs derived for the Feasibility Report and the GDM Study is shown in Table H-18.

26. Freeboard Requirements. - Freeboard allowances for wave runup and wind setup for Big Dry Creek and Fancher Creek Reservoirs were developed based on the criteria specified in the following references:

Wave Height, ETL 110-2-305, 16 Feb 1984.
Wave Runup, ETL 1110-2-221, 29 Nov 1976.
Wind Setup, "Shore Protection Manual", U.S Army Coastal Eng. Research Center, 1977.

Wind data from the Fresno Airport were used to find the critical wind speed and direction. The period of record for this station is 1949 to present. The wind directions examined were winds from the north, northeast and east for Big Dry Creek Reservoir and from the northeast, east, southeast and south for Fancher Creek Reservoir. Table H-19 shows the data found to be the most critical for the two reservoirs. Freeboard was set at 3 feet above Maximum Spillway Design Pool for Fancher and Big Dry Creek Reservoirs.

27. Results and Comparisons. - The hydrological results to be used for the project design features are shown in Table H-20. The same table shows corresponding peak flows used in the Feasibility Report. Inflow hydrographs of the main wave for the project for each feature are shown in Figures H-9 through H-17. The main wave along with the ratios of that main wave (see paragraph 22) were routed through the project features to determine the storage requirement. Project flood routings, inflows, outflows, and storages, are displayed in the operation section of this report. Three feet of freeboard was chosen for Big Dry Creek and Fancher Creek Reservoirs. No Probable Maximum Flood or wave runup was necessary on Alluvial Drain, Pup Creek or Redbank Creek Detention Basins because of height and type of embankment designed for each of these facilities. The following paragraphs compare the hydrology used for the GDM with the Feasibility Report hydrology.

a. Big Dry Creek Reservoir. - The Big Dry Creek project flood used to size the reservoir is a revision of the one found in the Feasibility Report. The precipitation depths over the basin, unit hydrograph procedure and loss rates were the same for the main wave. The only changes were the precipitation distribution and the ratios for the remaining five of the six waves. The precipitation distribution came from the Sacramento District's 1971 Standard Project Rainflood Criteria. The ratios came from the new frequency curves for Dry Creek at Academy. The present Design Standard Project Flood has a peak of 17,900 cfs, a main 5-day volume of 25,000 acre-feet and a total 30-day inflow volume of 52,400 acre-feet. These

Table H-16

Muskingum Routing Coefficients

Main Channel and Reach Description		Index Point From	Index Point To	Muskingum Coefficients Number of Reaches	K (Hrs.)	X
MUD CREEK						
Friant-Kern Canal	TO					
Enterprise Canal	TO	331730	331920	1	0.6	0.40
Gould Canal		331920	232540	1	0.9	0.40
REDBANK CREEK						
Loc. Abv. Enterprise C.	TO					
Gould Canal		230840	231940	4	3.7	0.50
DOG CREEK						
Loc. Abv. Enterprise C.	TO					
Dog Creek		230820	132430	10	10.0	0.50
PUP CREEK						
Loc. Blw. Friant-Kern C.	TO					
Abv. Enterprise Canal		223030	123530	3	3.2	0.20
DRY CREEK						
Friant-Kern Canal	TO					
Ltl. Dry Cr. Div. Channel		120320	120920	3	3.2	0.20
ENTERPRISE CANAL						
Gould Canal Split	TO					
Mud Creek		CSPLIT	332020	4	4.0	0.30
Canal Overflow	TO					
Gould Canal		ENTG12	232620	7	6.7	0.00
GOULD CANAL						
Enterprise Split	TO					
Mud Creek	TO	CSPLIT	232540	3	3.0	0.30
Local Below Mud Creek	TO	232540	232630	1	1.0	0.30
Local Below Fancher Cr.	TO	232630	232710	1	0.8	0.30
Next Local	TO	232710	232910	1	1.4	0.30
Redbank Creek	TO	232910	233010	1	1.9	0.30
Dog Creek	TO	233010	132430	1	1.5	0.30
Helm Canal	TO	132430	HELMCA	2	1.9	0.30
Dry Creek		HELMCA	GOULDC	2	1.8	0.30
FRESNO CANAL						
Mud Creek	TO					
Vernon Ditch	TO	GOUMUD	GOUDIV	1	0.7	0.35
Local Above Fancher Cr.	TO	GOUDIV	233431	1	1.8	0.35
Mill Ditch		233431	MILDTB	8	8.3	0.00
FANCHER CREEK						
Overland Flow below	TO					
The Enterprise Canal	TO					
Gould Canal		FANDIV	232710	1	4.0	0.00
Gould Canal Spill	TO					
Fresno Canal		232620	233430	1	0.8	0.40

HYDROLOGY APPENDIX

TABLE H-17

MODIFIED PULS STORAGE - DISCHARGE TABULATION

MAIN CHANNEL NAME

DESCRIPTION OF REACH

STORAGE : Values in Acre Feet

FLOW : Values in cubic feet per second

MUD CREEK

331730 routed under the Friant-Kern Canal.

STORAGE :	0	2	4	6	8	10	14	20	38	64.5	120	215
FLOW :	0	374	406	477	490	516	540	563	606	646	685	720

331920 routed under the Enterprise Canal.

STORAGE :	0.0	0.5	0.8	1.1	2.0	18.0	46.0	64.0	66.0	69.0	71.0	74.0	76.0	90.0
FLOW :	0.0	6.0	15.0	47.0	95.0	195.0	275.0	307.0	379.0	502.0	663.0	854.0	1064	2435

GOULD CANAL

Local 332730 routed into the Gould Canal.

STORAGE :	0.0	0.7	0.8	0.9	1.4	3.5	6.7	19.3	38.0	72.0	72.7	73.6	74.9	76.6
FLOW :	0.0	0.0	1.7	2.3	2.9	4.6	5.2	7.0	7.9	8.6	13.0	23.6	44.0	77.7

ENTERPRISE CANAL

332020 routed to 231820.

STORAGE :	0.0	4.9	10.4	23.6	39.5	48.1
FLOW :	0.0	43.0	92.0	208.0	350.0	424.0

231820 routed to 231331.

STORAGE :	0.0	2.9	6.1	13.1	23.1	28.2	30.0
FLOW :	0.0	43.0	92.0	208.0	350.0	424.0	800.0

Local 231331 routed into the Enterprise Canal.

STORAGE :	0.0	7.6	8.0	11.5	16	27
FLOW :	0.0	0.0	66.0	745.0	2100	5900

231331 routed over Fancher Creek to 231430

STORAGE :	0.0	3.0	6.3	14.4	24.0	29.3
FLOW :	0.0	43.0	92.0	208.0	350.0	424.0

Local 231430 routed into the Enterprise Canal.

STORAGE :	0.0	18.9	19.1	19.4	19.7	20.1	20.5	21.0	21.5	22.1	22.8
FLOW :	0.0	0.0	1.2	5.5	9.5	15.1	22.6	32.1	44.1	58.6	76.1

231430 routed to siphon under Redbank Creek (ENDIV1).

STORAGE :	0.0	5.8	12.4	28.1	47.0	57.2
FLOW :	0.0	43.0	92.0	208.0	350.0	424.0

Notes:

1. The locations or points described in this table refer to the Routing Diagram.

2. The Muskingum routing coefficients for the routing diagram are found in Table H-4.

MODIFIED PULS STORAGE - DISCHARGE
TABULATION

MAIN CHANNEL NAME
DESCRIPTION OF REACH
STORAGE : Values in Acre Feet
FLOW : Values in cubic feet per second

ENTERPRISE CANAL

From siphon under Redbank Creek to Tollhouse Road (123531).

STORAGE :	0.0	26.7	55.9	87.7	158.0	184.0
FLOW :	0.0	63.0	132.0	207.0	375.0	435.0

123531 routed into the Enterprise Canal.

STORAGE :	0.0	8.2	30.0	55.0	85.0	128.0
FLOW :	0	0	743	2100	3858	5938

123531 routed to Dry Creek.

STORAGE :	0.0	10.9	22.8	35.7	64.7	75.0
FLOW :	0	63	132	207	375	435

FANCHER CREEK

Fancher Creek Reservoir Outlet Rating Curve.

STORAGE :	0	198	555	1487	3930	9908	13955
FLOW :	0	20	40	60	80	101	110

Fancher Creek chute over the Friant-Kern Canal.

STORAGE :	0	32	44	62	110	135	165	205	240	286	342
FLOW :	0	60	170	313	673	884	1114	1361	1624	1902	2195
STORAGE :	405	460	520	580	615	681					
FLOW :	2500	2109	3151	4395	3670	4000					

Flow (231220) below the Friant-Kern Canal Routed to the Enterprise Canal.

STORAGE :	0	37	71	104	105	215	282	347
FLOW :	0	500	1000	1500	2000	3000	4000	5000

Flow at 231330 routed under the Friant-Kern Canal.

STORAGE :	0	0	5	10	20	30	40	50	60	70	85
FLOW :	0	1	800	1225	1750	2100	2350	2600	2900	3280	3900

232620 routed over the Gould Canal.

STORAGE :	0	1	2	5	8	13	18	20	23	24	25
FLOW :	0	0	400	675	800	1200	2080	3000	3950	4920	5910

232620 routed to the Fresno Canal (233430).

STORAGE :	0	68	96	120	166	214	355	403	479
FLOW :	0	500	800	1000	1500	2000	3000	4000	5000

REDBANK CREEK

222840 routed under the Friant-Kern Canal.

STORAGE :	0	1	2	4	20	35	60	90	120	170
FLOW :	0	130	150	160	170	180	190	200	250	334

MODIFIED PULS STORAGE - DISCHARGE
TABULATION

MAIN CHANNEL NAME
DESCRIPTION OF REACH
STORAGE : Values in Acre Feet
FLOW : Values in cubic feet per second

REDBANK CREEK

222840 routed through an unnamed reservoir.

STORAGE :	0	136	138	140	147	153	166	186	211	232	263	334
FLOW :	0	0	1	3	11	22	43	84	145	212	284	491

Outflow from unnamed reservoir routed to Redbank Reservoir.

STORAGE :	0	40	100	200	300	400	500
FLOW :	0	690	900	1200	1440	1610	1740

Local area 222730 routed under the Friant-Kern Canal.

STORAGE :	0	2	8	21	38	61	90	117
FLOW :	0	130	160	180	190	200	330	449

Local area 223410 routed under the Friant-Kern Canal.

STORAGE :	0	1	7	17	78	120	160	167
FLOW :	0	400	500	540	600	630	1200	1298

Local area 223530 routed under the Friant-Kern Canal.

STORAGE :	0	0.5	1	3	20	54	105	120	130
FLOW :	0	20	250	280	300	310	320	700	756

Flow below the Friant-Kern Canal routed to Redbank Creek Reservoir.

STORAGE :	0	75	140	200	240	255	290	360	410
FLOW :	0	100	250	500	1000	1500	1750	2000	2100

Redbank Creek Reservoir (REDBNK) with one outlet open + Spillway.

STORAGE :	0	1.0	2.0	5.0	10	40	140	365	1030	1130	1250	1500	1750
FLOW :	0	6.0	14.2	19.5	27	40	50	58.5	66	106.4	207	567	1024
STORAGE :	2050	2400	2780	3050									
FLOW :	1571	2197	2891	4212									

Redbank Creek Reservoir (REDBNK) with both outlets open + Spillway.

STORAGE :	0	1.0	2.0	5.0	10	40	140	365	1030	1130	1250	1500	1750
FLOW :	0	12.0	28.4	39.0	54	80	100	117	132	172.8	274	696	1240
STORAGE :	2050	2400	2780	3050									
FLOW :	1872	2764	3486	5172									

Local 231030 routed under the Enterprise Canal.

STORAGE :	0	0.05	0.1	0.2	0.5	1.4	4.0	10.0	10.8	11.8
FLOW :	0	5.00	5.6	6.2	8.3	12.2	19.8	23.3	80.2	215.0

Upper Clovis Lake (231610).

STORAGE :	0	15.6	19.9	20.0	23.9	31	37	73	74	75
FLOW :	0	0.0	16.7	16.9	19.7	24	27	36	73	161

Local 231510 routed under the Enterprise Canal.

STORAGE :	0	7.0	9.1	9.5	10.6	12.0	18.9	27.3	28.2	29.7
FLOW :	0	0.0	11.4	12.4	14.9	17.7	21.3	32.1	82.0	217.0

Lower Clovis Lake (231640).

STORAGE :	0	108	125	163	187
FLOW :	0	0	35	368	1132

HYDROLOGY APPENDIX
TABLE H-17 (Continued)

MODIFIED PULS STORAGE - DISCHARGE
TABULATION

MAIN CHANNEL NAME
DESCRIPTION OF REACH
STORAGE : Values in Acre Feet
FLOW : Values in cubic feet per second

REDBANK CREEK

Flows below the Enterprise Canal routed to the Gould Canal.

STORAGE	:	0	146	278	346	573	973
FLOW	:	0	500	1000	1500	2000	2800

Local 230840 routed under the Enterprise Canal.

STORAGE	:	0	0.6	1.4	5.6	8.0	12.0	41.0	85.0	156.0	265.0	272.0	278.0
FLOW	:	0	27.1	29.1	34.3	36.6	38.7	45.5	51.4	56.6	64.0	129.5	222.3

Flow at 231940 routed over the Gould Canal Siphon.

STORAGE	:	1	14	28	56	70	84	118	144	226	310
FLOW	:	0	65	125	235	300	380	575	1260	2040	7500

231940 below the Gould Canal routed to Dog Creek.

STORAGE	:	0	25	145	225	270	320	365	400
FLOW	:	0	100	500	1000	2000	3000	4000	5000

Routed from Dog Creek to Redbank Creek Detention Basin (DETENB).

STORAGE	:	0	80	140	160	190	220	250	280
FLOW	:	0	100	500	1000	2000	3000	4000	5000

Redbank Creek Detention Basin (DETENB).

STORAGE	:	0	17	18	1000
FLOW	:	0	190	200	201

DOG CREEK

Local at 222820 routed under the Friant-Kern Canal.

STORAGE	:	0	5	9	13	17	20	23	25	30
FLOW	:	0	0	50	100	150	200	250	300	350

Local at 230710 routed under the Enterprise Canal.

STORAGE	:	0.00	0.01	0.04	0.18	5.0	19.1	19.6	20.3
FLOW	:	0.00	2.40	3.40	5.70	9.2	17.4	66.9	201.0

Local at 230820 routed under the Enterprise Canal.

STORAGE	:	0.0	1.9	4.1	9.7	17.8	24.4	80.0	218.0	226	235	249
FLOW	:	0.0	19.9	21.0	23.4	26.6	28.5	31.0	33.3	90	225	487

Flow at 130720 below the Enterprise Canal routed to the Gould Canal (132430).

STORAGE	:	0	170	285	355	455	510
FLOW	:	0	50	100	200	300	400

Flow at 132430 routed under the Gould Canal.

STORAGE	:	0	30	50	75	100	140
FLOW	:	0	50	100	200	300	400

TABLE H-17 (Continued)

MODIFIED PULS STORAGE - DISCHARGE
TABULATION

MAIN CHANNEL NAME
DESCRIPTION OF REACH
STORAGE : Values in Acre Feet
FLOW : Values in cubic feet per second

DOG CREEK
Flows at 132430 below the Gould Canal routed to Redbank Creek.

STORAGE	:	0	10	20	30	35	40
FLOW	:	0	50	100	200	300	400

PUP CREEK
123530 routed under the Enterprise Canal.

STORAGE	:	0	1	7	11	14	15	16	17	18	19	20	21
FLOW	:	0	11	37	40	42	45	62	105	181	296	454	662

130120 routed under the Enterprise Canal.

STORAGE	:	0	40	80	119	160	209	255	301	350	398	450	480	502	550
FLOW	:	0	6	10	13	15	17	19	20	22	23	25	25	26	27

130130 routed under the Enterprise Canal..

STORAGE	: 0.0	0.02	0.2	0.7	0.9	3.0	24.6	66.5	135.0	143.0	149.0	167	224
FLOW	: 0.0	6.80	7.5	8.2	8.6	8.7	9.1	9.8	10.3	77.9	170.0	550	2510

Pup Creek Detention Basin (PUPDTB).

STORAGE	:	0	87	126	223	239	460	1000
FLOW	:	0	5	10	15	20	25	26

DRY CREEK
Local area 222020 routed under the Friant-Kern Canal.

STORAGE	:	0	2	7.1	14.8	20.9	128	462	466	473	484	498
FLOW	:	0	212	239	275	300	350	390	422	534	782	1221

Local area 221810 routed under the Friant-Kern Canal.

STORAGE	:	0	2.6	9.6	20	28.5	125	320	324	334	352	378
FLOW	:	0	152	174	201	221	258	292	341	682	1602	3392

Local area 220730 routed under the Friant-Kern Canal.

STORAGE	:	0	0.8	3.2	7.2	14.9	27.8	92	93.4	97.4	104
FLOW	:	0	600	703	850	1076	1240	1463	1505	1774	2492

Local area 121230 routed under the Friant-Kern Canal.

STORAGE	:	0	3.1	10.8	18.0	31.6	56.1	73.1	74.2	76.3	79.4	83.5
FLOW	:	0	123	137	148	163	187	205	283	575	1222	2367

Local area 121130 routed under the Friant-Kern Canal.

STORAGE	:	0	0.2	0.5	0.6	1.0	1.5	2.3	5.0	64.0
FLOW	:	0	15.0	27.0	58.0	77.0	92.0	107.0	122.0	177.0

MODIFIED PULS STORAGE - DISCHARGE
TABULATION

MAIN CHANNEL NAME
DESCRIPTION OF REACH
STORAGE : Values in Acre Feet
FLOW : Values in cubic feet per second

LITTLE DRY CREEK DIVERSION CHANNEL

Local area 121120 routed under the Friant-Kern Canal.

STORAGE :	0	0.2	0.5	0.8	1.8	5	12	12.5	13.5
FLOW :	0	62	67	72	87	120	142	602	1690

Local area 120340 routed under the Friant-Kern Canal.

STORAGE :	0	0.3	0.6	1.0	2.2	4.0	6.0	8.8	15.0	18.9
FLOW :	0	319	344	373	448	540	634	716	752	2210

Local area 120330 routed under the Friant-Kern Canal.

STORAGE :	0	0.5	1.2	3.0	6.2	8.6	12.3	20.4	21.4	22.7
FLOW :	0	62	67	79	97	109	124	144	544	1490

Local area 120320 routed under the Friant-Kern Canal.

STORAGE :	0	0.5	1.2	3.1	6.4	8.9	12.7	22.0	28.6	30.0	32.0	36.1
FLOW :	0	89	96	114	139	157	180	204	209	557	1580	2980

Routing of flows through the Little Dry Creek Diversion Channel to Little Dry Creek.

STORAGE :	0	35	47	75	126	265	385	464	737	820	1089
FLOW :	0	0	25	85	180	420	615	705	1000	1085	4300

FRESNO CANAL

Flow at Fancher Creek (233430) routed to Mill Ditch Diversion.

STORAGE :	0	104	157	171	195	218	260	360
FLOW :	0	10	100	200	400	600	1000	2000

MILL DITCH

Flow at the Fresno Canal routed to Redbank Detention Basin (Temperance Ave).

STORAGE :	0	7	18	27	41	54	77	122
FLOW :	0	10	100	200	400	600	1000	2000

Flow at Temperance Ave. (132640) routed to Clovis Ave. (132830).

STORAGE :	0	7	25	38	60	79	112	188
FLOW :	0	10	100	200	400	600	1000	2000

Flow at Clovis Ave. (132830) routed to Herndon Canal.

STORAGE :	0	61	71	75	84	93	112	157
FLOW :	0	10	100	200	400	600	1000	2000

ALLUVIAL DRAIN

Alluvial Drain Detention Basin.

STORAGE :	0	155	310	414	1000
FLOW :	0	13	21	25	26

Table H-18

Probable Maximum Flood Runoff

Inflow Location	Peak Flow (cfs) Feasibility Study	Peak Flow (cfs) GDM	72-hour Volume (acre-feet) Feasibility Report	72-hour Volume (acre-feet) GDM
Big Dry Creek Reservoir	45,000	45,400	66,800	66,800
Dog Creek Diversion to Big Dry Creek	11,700 1/	12,000	14,200 1/	13,800
Fancher Creek Reservoir	19,200	20,600	17,600	20,600

1/ July 1980 Study

Table H-19

Design Wave Runup

	Big Dry Creek Reservoir	Design Wave Runup Fancher Creek Reservoir
Average Fetch (miles)	2.48	1.24
Elevation of Computation 1/	439.1	491.3
Design Wind		
Wind Direction	NE	NE
Design Wind (MPH)	35	35
Wind Duration (min)	33	33
Design Wave		
Significant Wave Height (Hs-ft)	2.02	1.60
Significant Wave Period (Ts-sec)	2.65	2.20
Wave Length (ft)	36.0	24.8
Wave Runup		
Side Slope of Dam (Vert/Hor)	1/3	1/3
Significant Runup (Rs-ft)	2.31	1.38
Wind Setup (s-ft)	0.202	0.109
Wave Runup (ft)	2.51	1.49

1/ The Pool Elevation used for computational purposes was the maximum Spillway Design Pool.

results were used to size Big Dry Creek Reservoir. The Feasibility Report SPF peak flow is 19,700 cfs, with a 5-day main wave volume of 33,000

acre-feet and a 30-day inflow volume of 64,300 acre-feet. Inflow, outflow, and storage routings of these floods are displayed in the Reservoir Operation Section of this report.

b. Fancher Creek Reservoir. - GDM peak flows for Fancher Creek are slightly greater than the Feasibility Report peak flows, Table H-20. The difference is minimal and will not cause any change in the project or preproject flood plains. Reservoir inflow values found in Table H-20 reflect peak flows just upstream of the Friant-Kern Canal. Fancher Creek at Mill Ditch is the same as the Fresno Canal just before the headworks of the Mill Ditch - Fancher Creek split.

c. Redbank Creek Detention Basin. - The two important index points on Redbank Creek and Mill Ditch are Redbank Creek at the proposed detention basin site just before entering Mill Ditch, and Mill Ditch at Temperance Ave. Redbank Creek project flows for this report are less than the feasibility study flows for three reasons: (1) the improved routing procedures in this study better reflect storage routings through the Enterprise and Gould Canals and overland routings; (2) a slight decrease in peak and volume inflow into the upstream Redbank Creek Reservoir; and (3) Redbank Reservoir was operated with both gates open instead of one gate as in the Feasibility Report. The present project controls the 200-year flood to an outflow of 200 cfs, while the Feasibility Report hydrology spilled a peak flow of 900 cfs into Mill Ditch. There is no difference in peak flow at Temperance Avenue under preproject conditions.

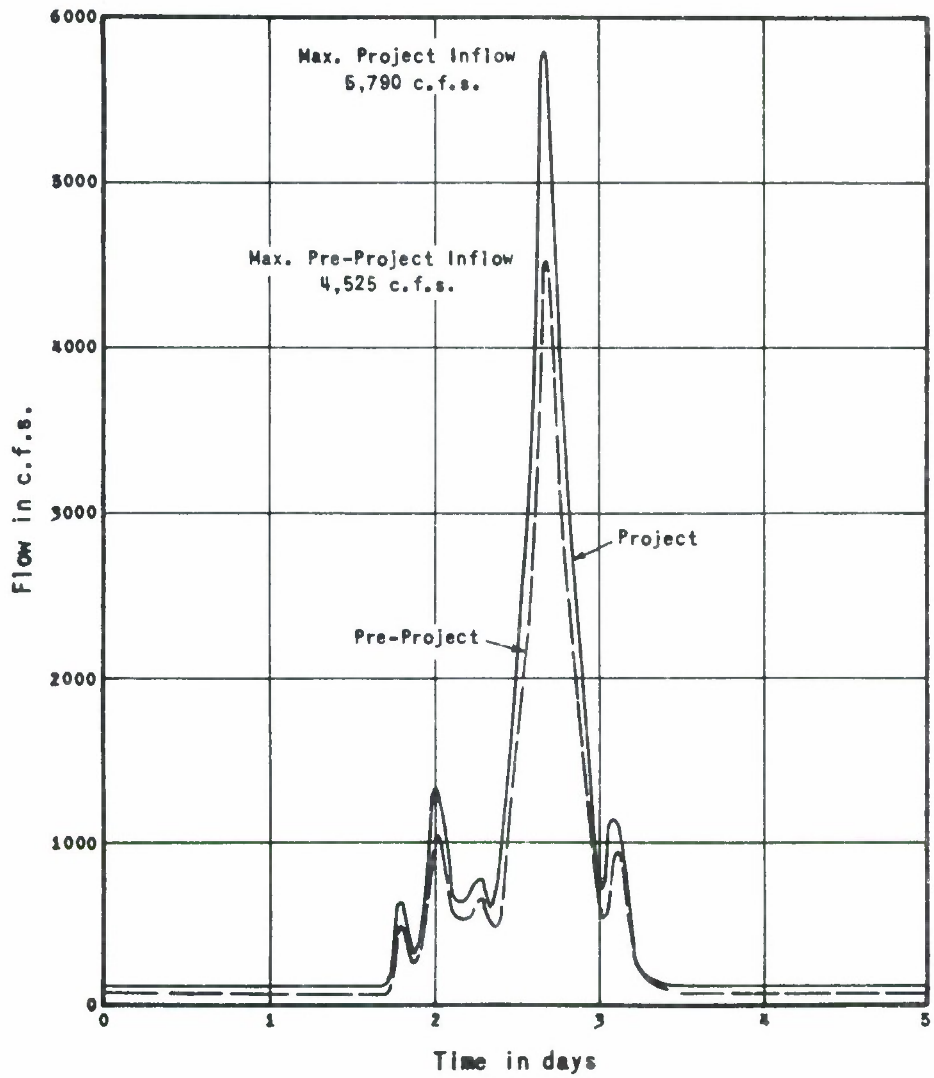
d. Alluvial Drain and Pup Creek. - 200-year 6-hour cloudburst storms found in the feasibility report were centered over Alluvial Drain and Pup Creek basin, and produced inflows of 1,750 cfs and 1,600 cfs, respectively, into the proposed detention basins. The resulting volumes generated from these two storms are 230 acre-feet for Alluvial Drain and 280 acre-feet for Pup Creek. The 200-yr 30-day general rain flood produced smaller peak flows than the cloudburst event; however, the runoff volumes are greater. The detention basin for each stream was designed using the larger runoff volume, i.e., 385 acre-feet for Alluvial Drain Detention Basin and 500 acre-feet for Pup Creek Detention Basin. No PMF values were calculated for these detention basins because no spillway is required.

TABLE H-20

Peak Flow Comparison of General Design Memorandum Results With the Feasibility Report

Location	Design Memorandum						Feasibility Report			
	Preproject			Project 1/			Preproject 2/		Project 2/	
	D.A 3/ (Sq. mi.)	Peak Flow (cfs)	CSM	D.A. (Sq. mi.)	Peak Flow (cfs)	CSM	Peak Flow (cfs)	CSM	Peak Flow (cfs)	CSM
Fancher Creek at Reservoir Inflow (Friant-Kern Canal)	20.87	4,520	216.6	27.87	5,790	207.8	4,150	198.9	5,400	193.8
Mill Ditch	47.13	3,620	4/		1,240	4/	3,150		1,100	4/
Temperance Ave.	47.13	2,200			1,000		2,200		900	
Redbank Creek above Mill Ditch	32.17	1,920		25.17	200		2,500		900	
Temperance Ave. (Mill Ditch of Temperance Ave.)	34.12	3,360		27.12	290		3,300		900	
Alluvial Drain Detention Basin	2.65	340	128.3	2.65	25		5/1,750	655	25	
Pup Creek Detention Basin	4.26	315	73.9	4.26	25		5/1,600	375.6	25	
Big Dry Creek Reservoir	81.67	17,900	219.2	81.67	17,900		19,700	241.2	19,700	

1/ Project Floods all locations except Big Dry Creek Reservoir is the 200-year flood event. The project flood for Dry Creek is the Standard Project Flood.
2/ Feasibility Report drainage areas for locations given in this table are the same as given in the Design Memorandum Drainage Area columns (D.A.).
3/ Drainage area in the D.A. column is the natural contributating area above that point, actual contributating drainage area will vary depending on interbasin flow.
4/ No values appear in the CSM column when interbasin flow occures when total contributing drainage area is unknown and/or the peak flow is routed through a project feature.
5/ These peaks result from a 6-hr 200-year cloudburst storm from the Feasibility report.



NOTES:

1. Preproject flow reflects Fancher and Hog Creeks at the Friant-Kern Canal.
2. Project reflects the above flow plus all flow from the Redbank Tributaries east of Madsen Avenue.
3. Total Preproject main wave volume and base flow is 4420 acre-feet.
4. Total Project main wave volume and base flow is 5580 acre-feet.

Preproject D.A.: 20.87 sq. mi.
Project D.A.: 27.85 sq. mi.

REDBANK AND FANCHER CREEKS
CALIFORNIA

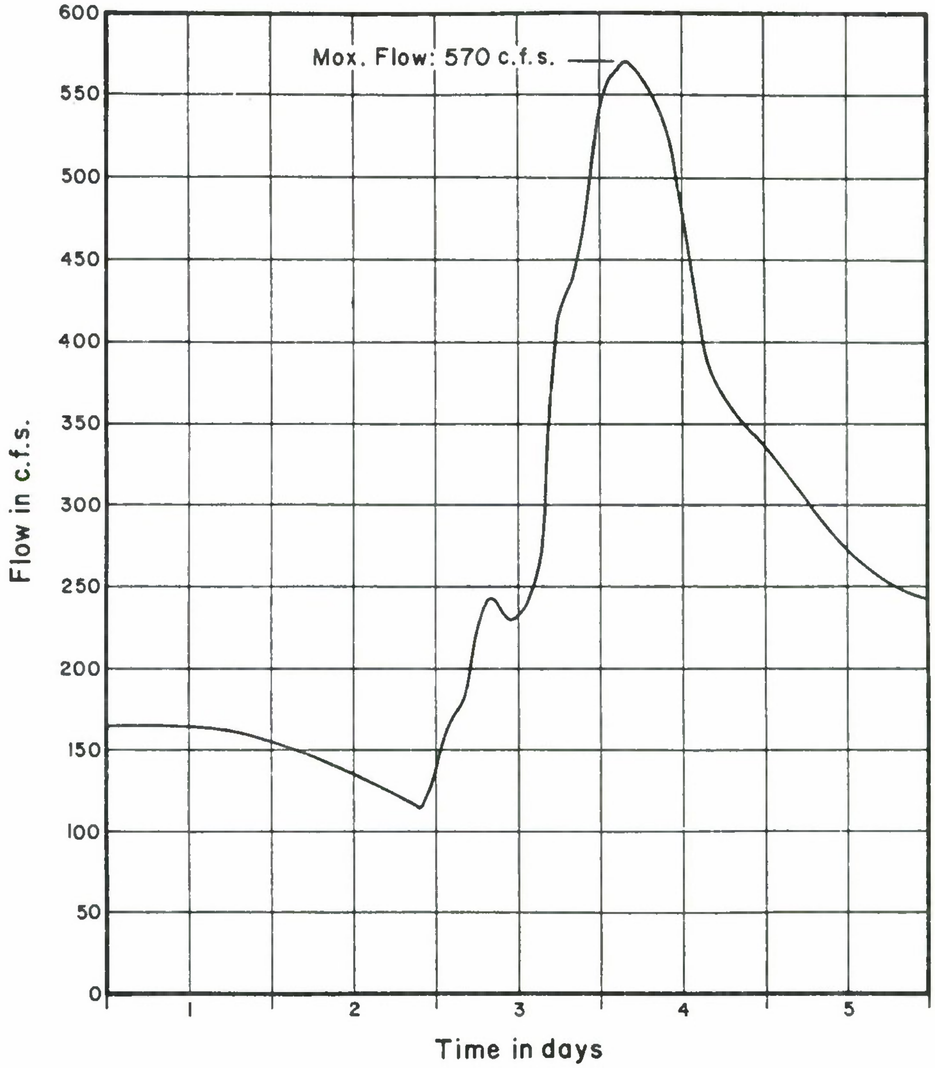
200 YEAR FLOOD
MAIN WAVE

FANCHER CREEK DAM SITE

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: R.F.C.
Drawn: C.A.P.
Date:

FIGURE H-9



NOTES:
This inflow hydrograph reflects the following upstream conditions:

A. All tributaries East of Madsen Avenue are diverted into Fancher Creek Reservoir.
B. Redbank Creek Reservoir has both outlet gates full open.
C. No flow from the Enterprise Canal enters Redbank Creek above the Redbank Creek detention basin.
D. Gould Canal Siphon under Redbank Creek is set to pass 90 c.f.s. with excess spilling into Redbank Creek.

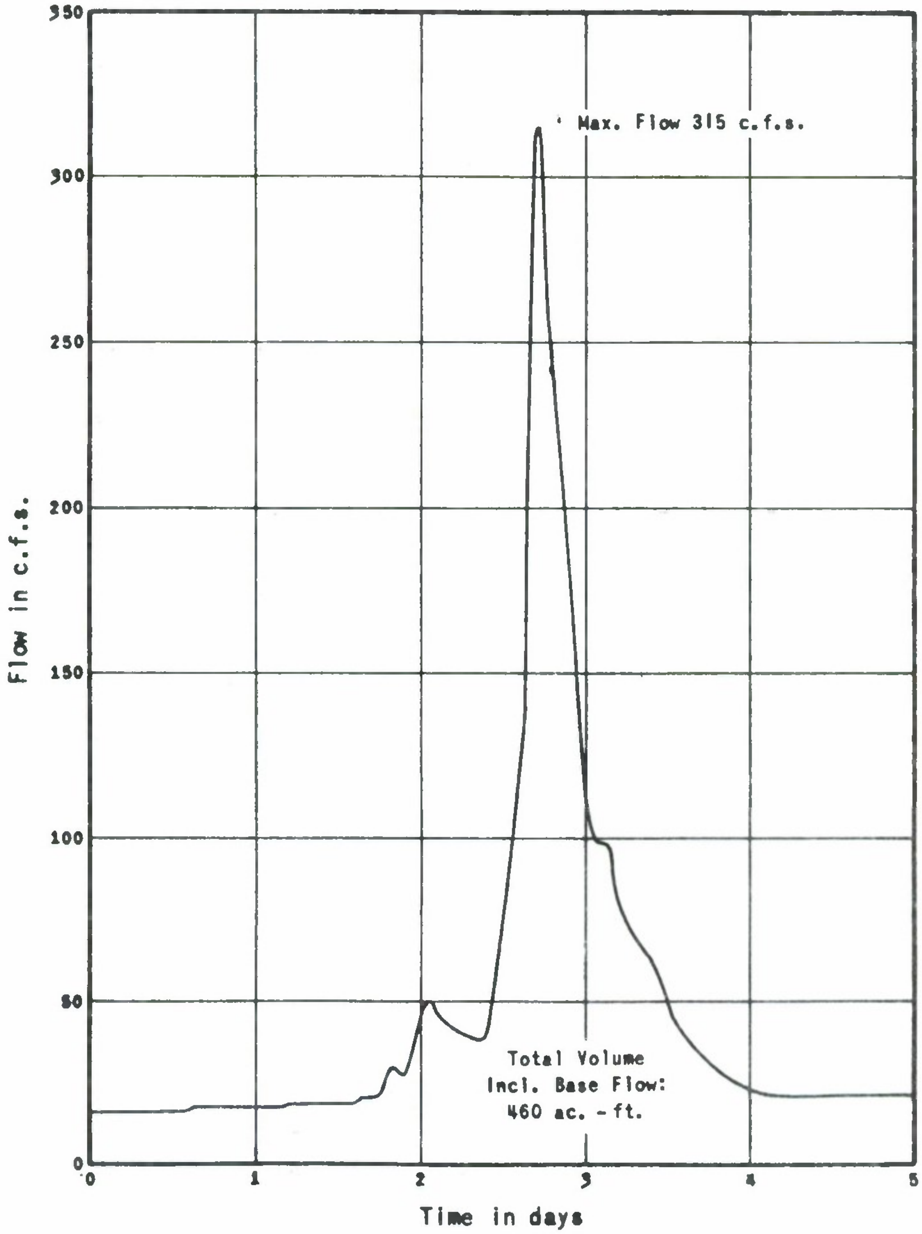
REDBANK AND FANCHER CREEKS
CALIFORNIA

200 YEAR FLOOD
MAIN WAVE INFLOW

REDBANK CREEK DETENTION BASIN

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: R.F.C.
Drawn: C.A.P.
Date:



REDBANK AND FANCHER CREEKS
CALIFORNIA

200 YEAR FLOOD
MAIN WAVE INFLOW

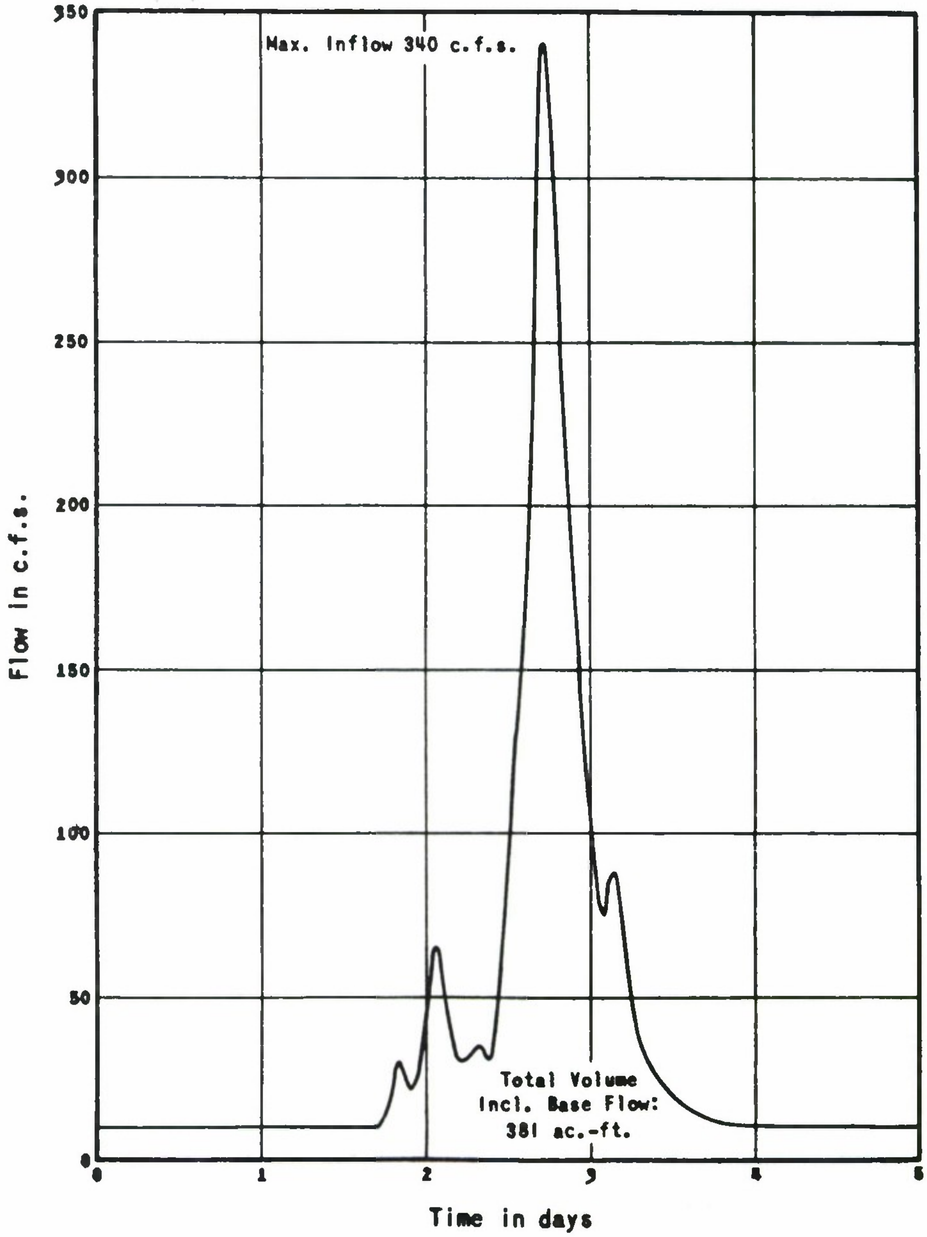
PUP CREEK DETENTION BASIN

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: R.F.C. Date:
Drawn: C.A.P.

Drainage Area: 4.26 sq. mi.

FIGURE H-II



Drainage Area: 2.65 sq. mi.

REDBANK AND FANCHER CREEKS
CALIFORNIA

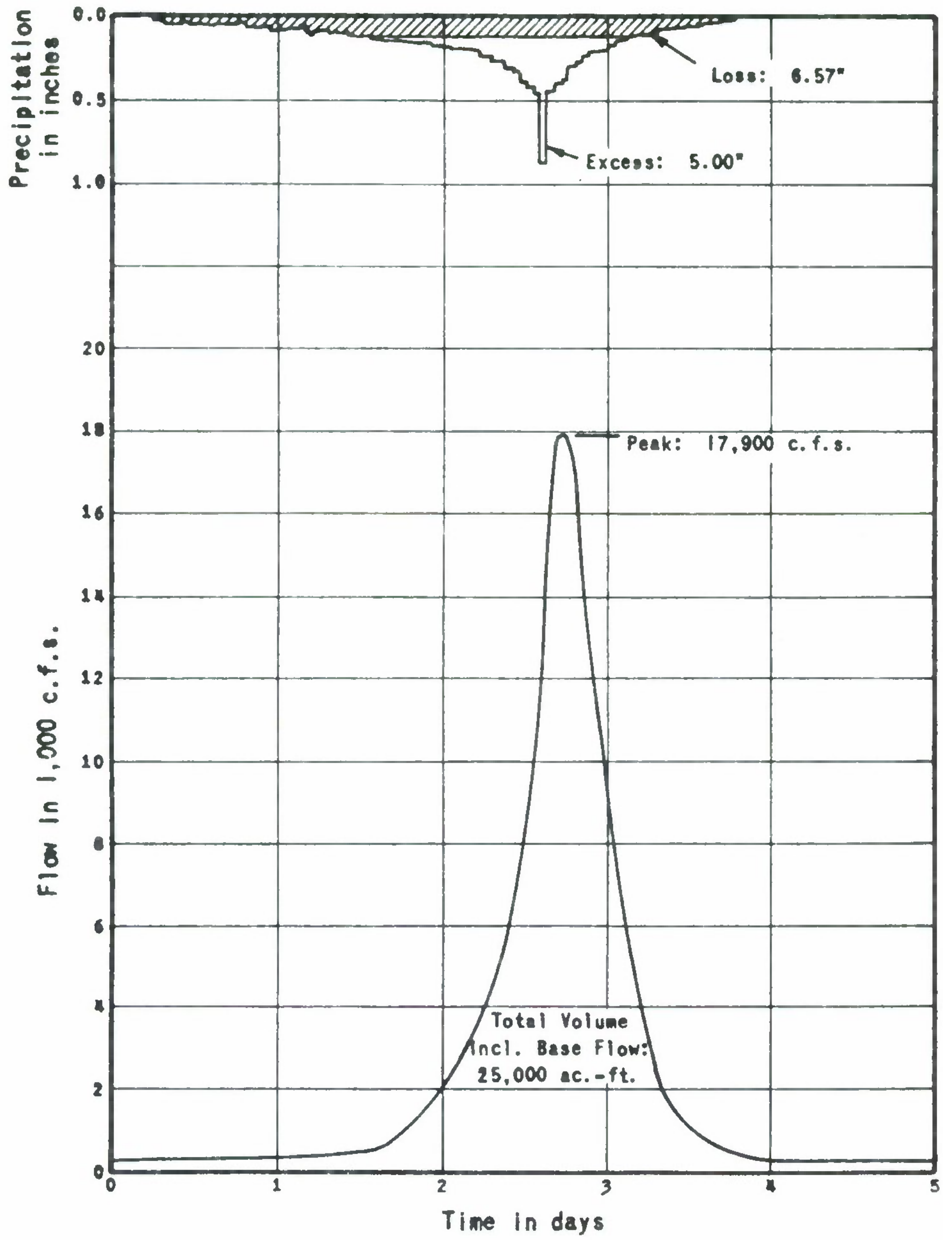
200 YEAR FLOOD
MAIN WAVE INFLOW

ALLUVIAL DRAIN DETENTION BASIN

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: R.F.C.
Drawn: C.A.P.
Date:

FIGURE H-12



Drainage Area: 81.7 sq. mi.

REDBANK AND FANCHER CREEKS
CALIFORNIA

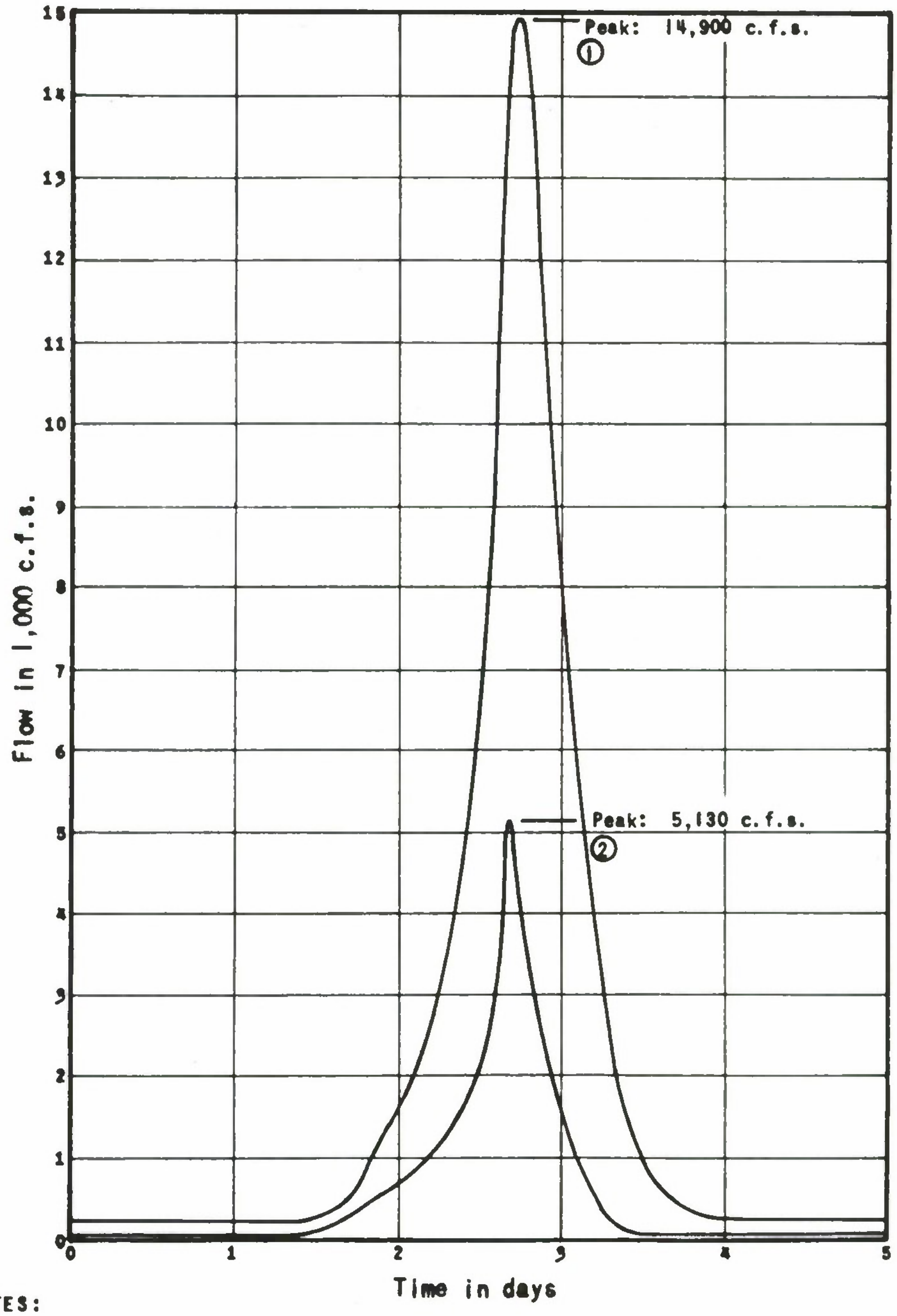
STANDARD PROJECT FLOOD
MAIN WAVE

INFLOW TO BIG DRY CREEK RESERVOIR

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: R.F.C. Date:
Drawn: C.A.P.

FIGURE H-13



NOTES:

1. Dry Creek and Dog Creek at Friant-Karn Canal Syphon, D.A. = 64.5 sq. mi. Total volume incl. base flow = 20,700 ac.-ft.
2. Dog Creek at Dog Creek Diversion to Big Dry Creek Reservoir, D.A. = 14.9 sq. mi. Total volume incl. base flow = 5,580 ac.-ft.

REDBANK AND FANCHER CREEKS
CALIFORNIA

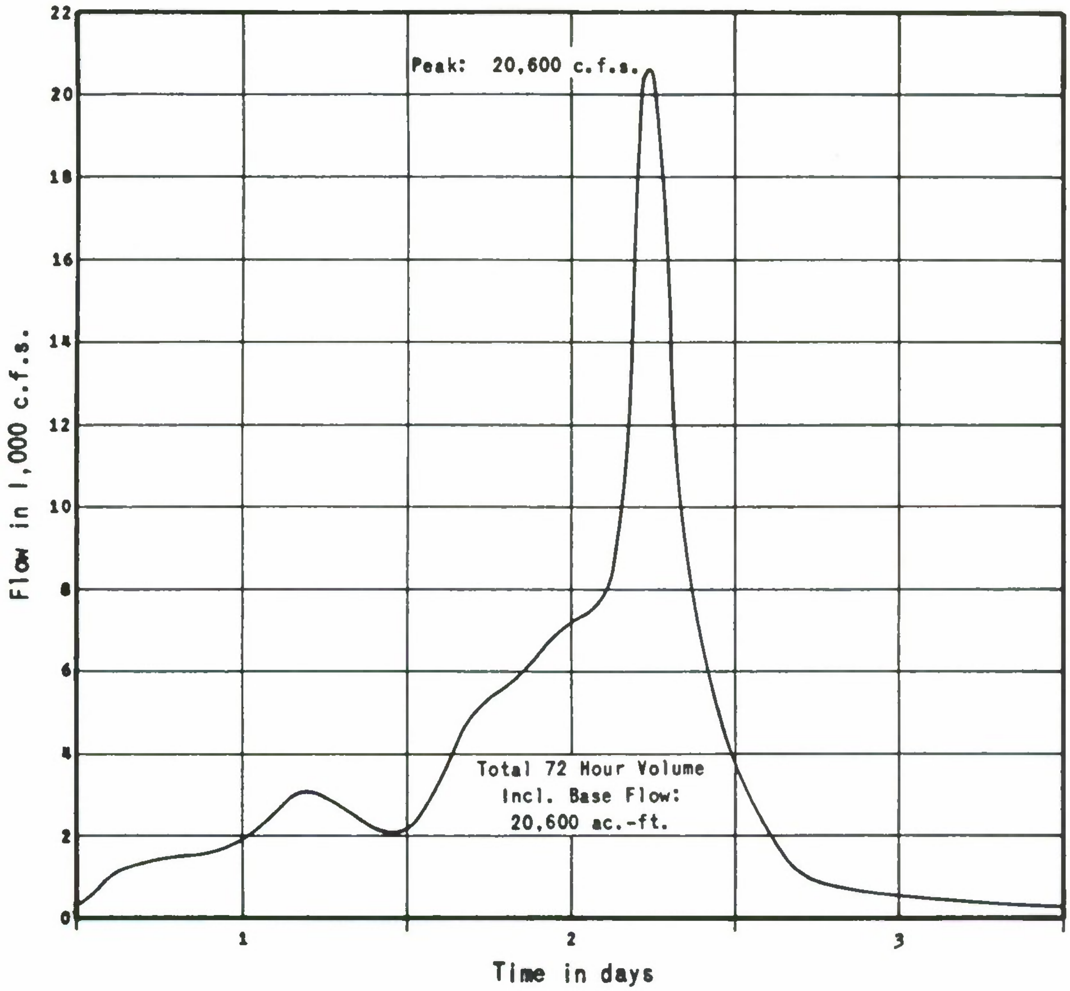
STANDARD PROJECT FLOOD
MAIN WAVE

DRY CREEK AT FRIANT KERN CANAL

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: R.F.C. Date:
Drawn: C.A.P.

FIGURE H-14



Drainage Area: 27.85 sq. mi.

REDBANK AND FANCHER CREEKS
CALIFORNIA

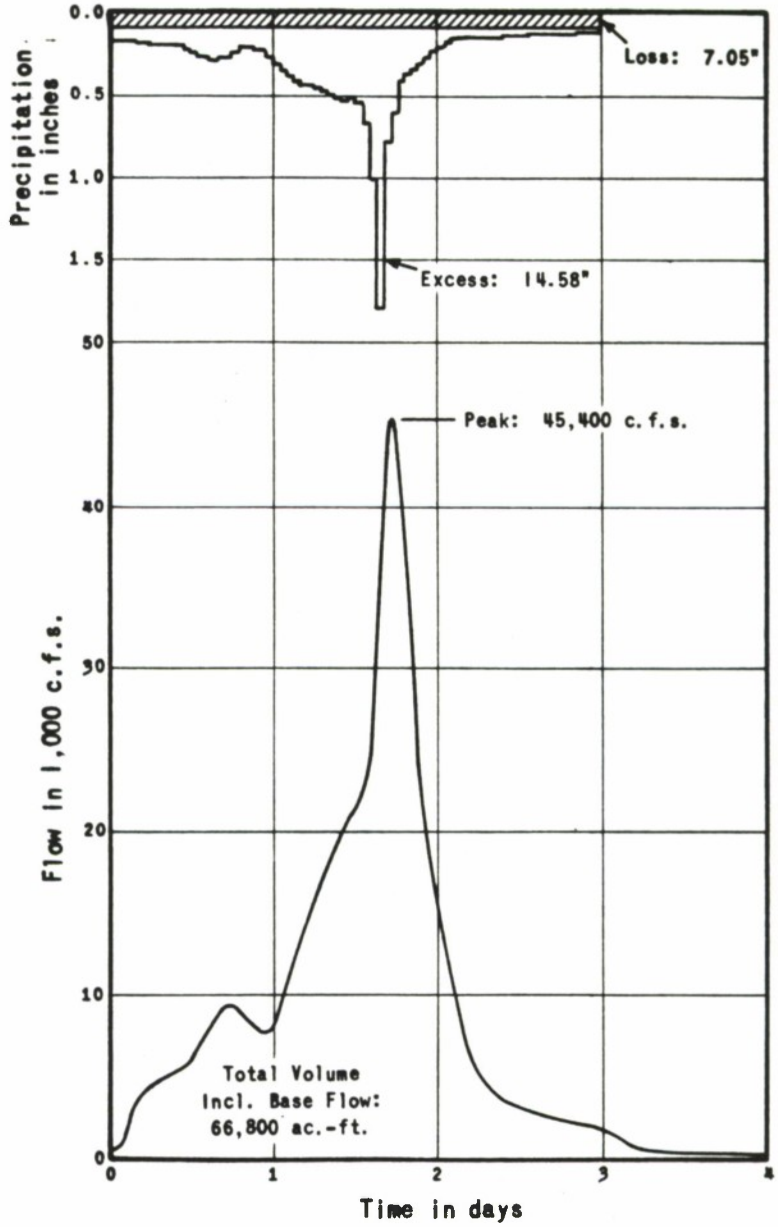
PROBABLE MAXIMUM FLOOD
INFLOW

FANCHER CREEK RESERVOIR

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: R.F.C.
Drawn: C.A.P.
Date:

FIGURE H-15



Drainage Area: 81.7 sq. mi.

REDBANK AND FANCHER CREEKS
CALIFORNIA

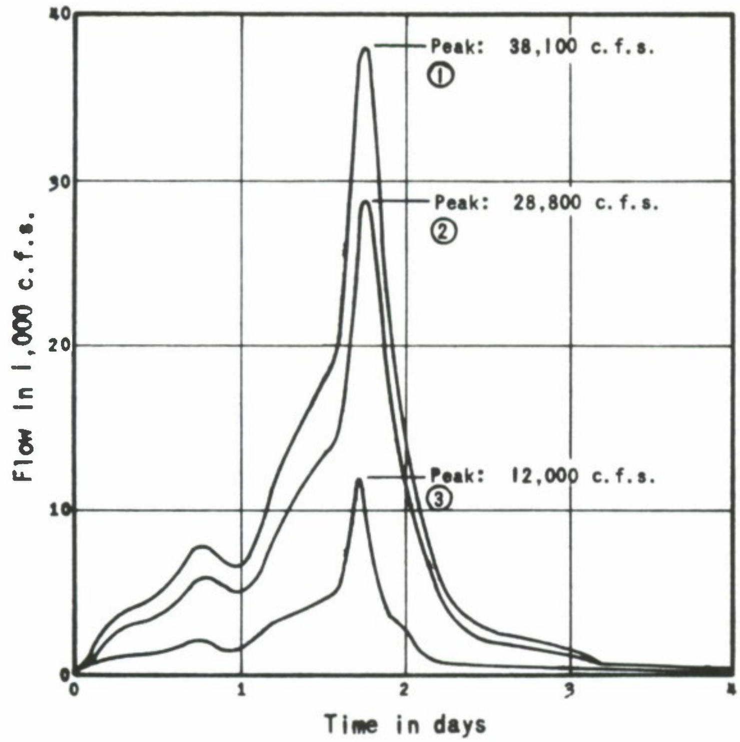
PROBABLE MAXIMUM FLOOD

INFLOW TO BIG DRY CREEK RESERVOIR

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: R.F.C.
Drawn: C.A.P.
Date:

FIGURE H-16

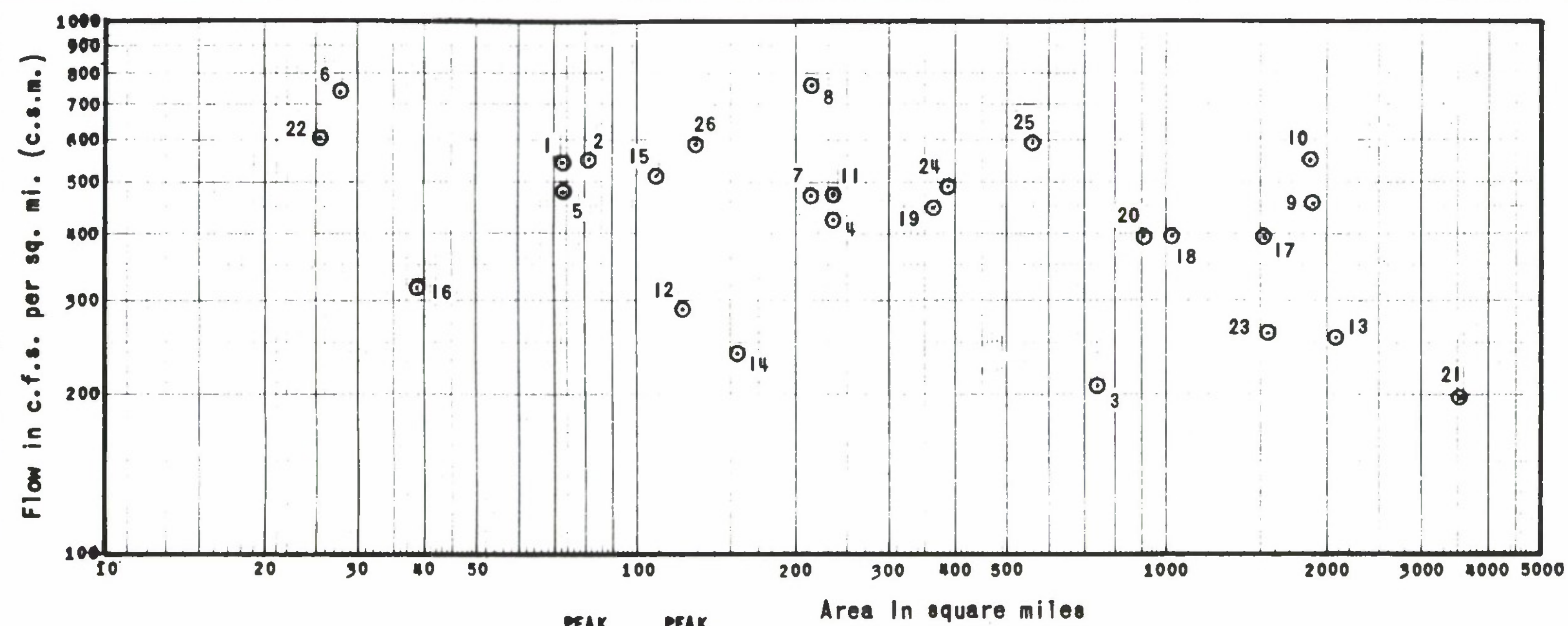


NOTES:

1. Dry Creek and Dog Creek at Friant-Kern Canal Syphon, D.A. = 64.5 sq. mi. Total volume incl. base flow = 56,400 ac.-ft.
2. Dry Creek at Friant-Kern Canal Syphon without Dog Creek, D.A. = 49.6 sq. mi. Total volume incl. base flow = 42,700 ac.-ft.
3. Dog Creek at Dog Creek Diversion to Big Dry Creek Reservoir, D.A. = 14.9 sq. mi. Total volume incl. base flow = 13,700 ac.-ft.

REDBANK AND FANCHER CREEKS CALIFORNIA PROBABLE MAXIMUM FLOOD DRY CREEK AT FRIANT KERN CANAL
CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA
Prepared: R.F.C. Date: Drawn: C.A.P.

FIGURE H-17



NO.	RESERVOIR	D.A. (sq. mi.)	PEAK INFLOW (c.f.s.)	PEAK INFLOW (c.s.m.)
1	Bear	72.1	38,900	540
2	Big Dry Creek	81.7	45,400	556
3	Black Butte	741.0	154,000	208
4	Buchanan	235.0	105,800	450
5	Burns	72.2	34,300	475
6	Fancher Creek	27.8	20,600	741
7	Farmington w/o upstream failure	212.0	100,000	471
8	Farmington w upstream failure	212.0	161,000	759
9	Folsom w/o upstream failures	1,875.0	848,000	452
10	Folsom w upstream failures	1,875.0	1,037,000	553
11	Hidden	234.0	111,000	473
12	Indian Valley	121.0	35,000	289
13	Isabella	2,074.0	530,000	256
14	Los Banos	156.0	37,000	237
15	Mariposa	109.0	55,800	512
16	Martis Creek	39.0	12,400	318
17	New Don Pedro	1,533.0	602,000	393
18	New Exchequer	1,037.0	411,000	396
19	New Hogan	363.0	162,500	448
20	New Melones	904.0	355,000	393
21	Oroville	3,611.0	720,000	199
22	Owens	25.6	15,500	605
23	Pine Flat	1,542.0	400,000	259
24	Success	388.0	190,000	490
25	Terminus	560.0	330,000	589
26	Warm Springs	130.0	77,000	592

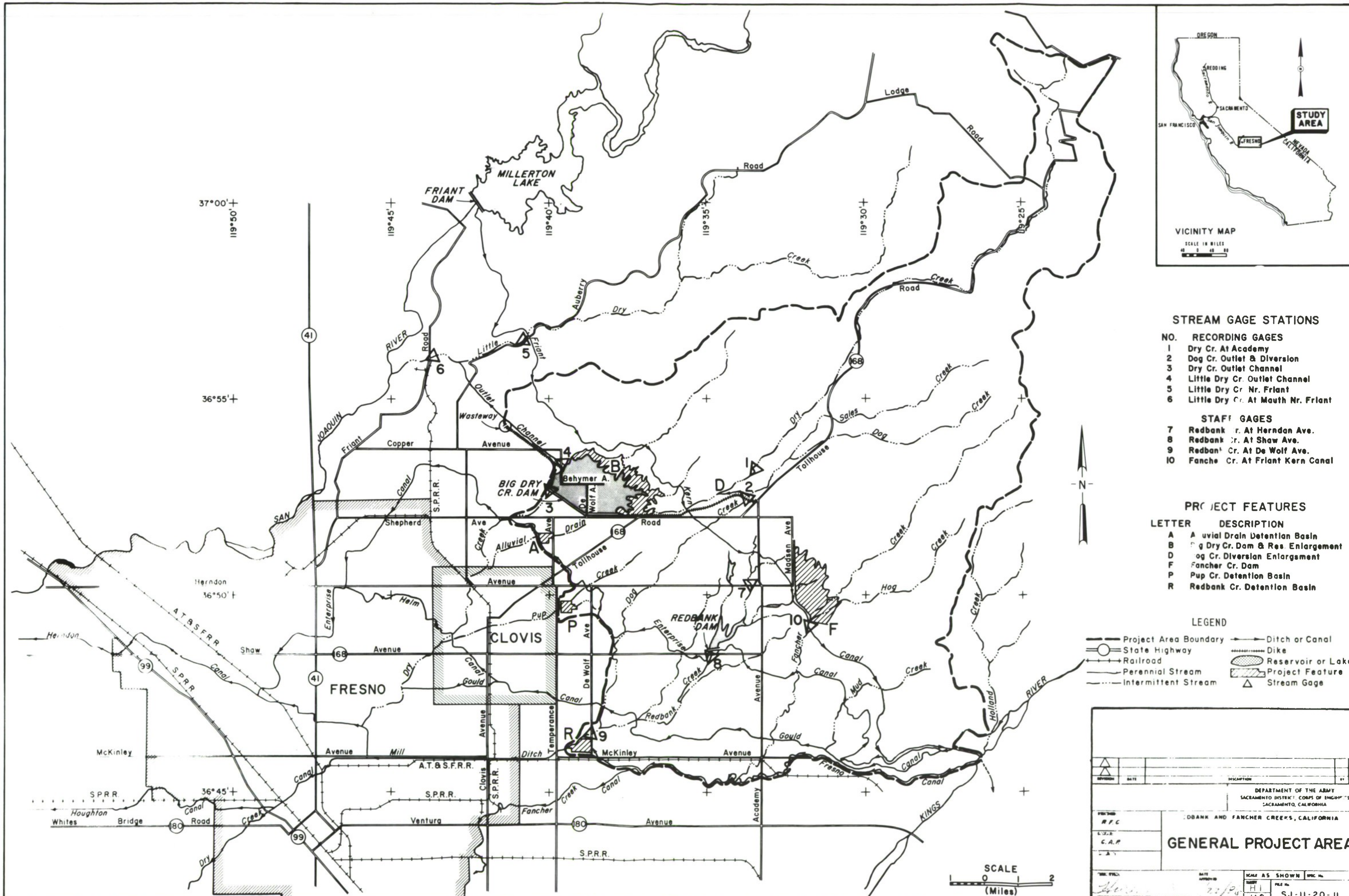
REDBANK AND FANCHER CREEKS
CALIFORNIA

COMPARISON OF PROBABLE MAXIMUM FLOODS IN CALIFORNIA

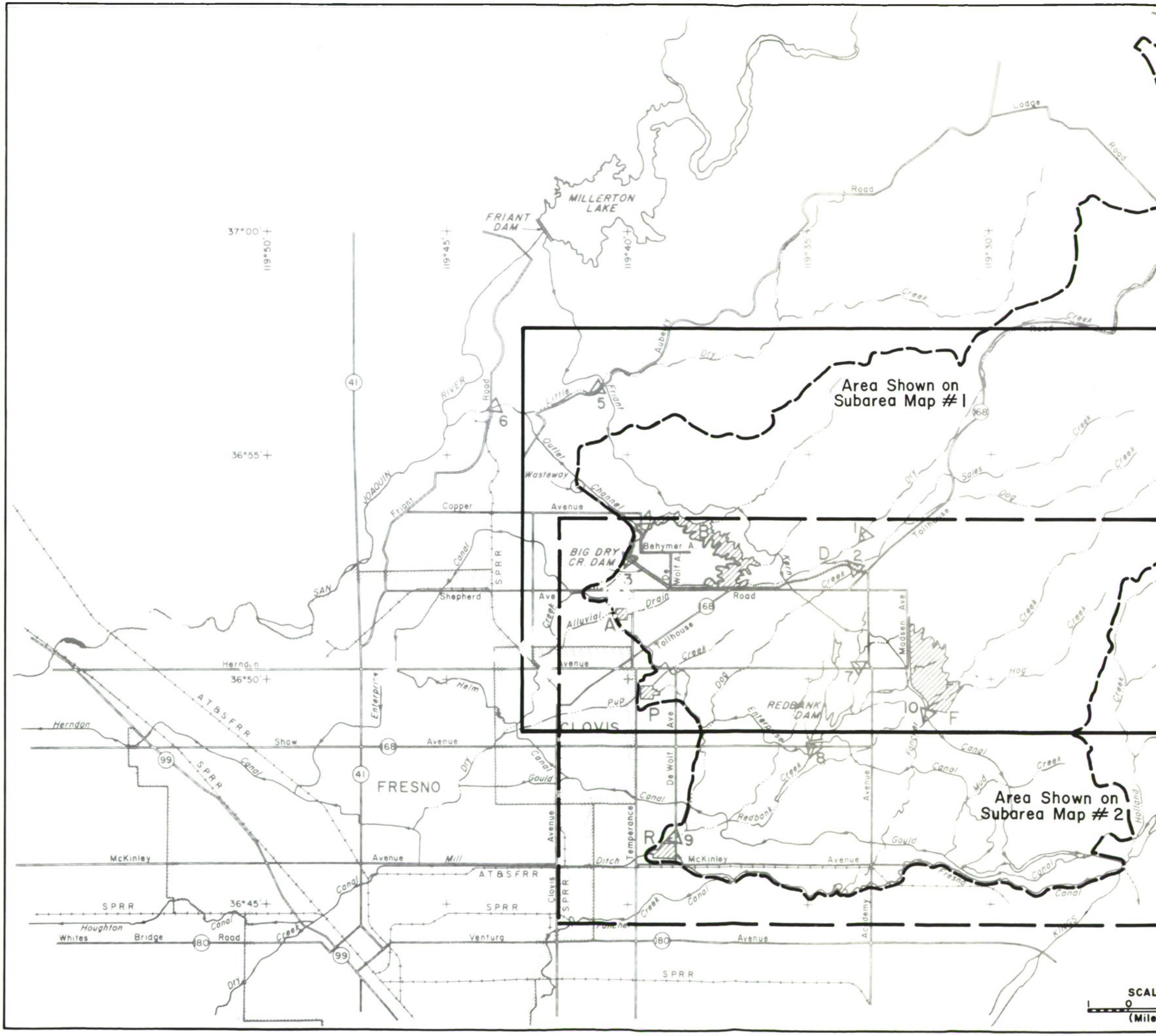
CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: R.F.C
Drawn: C.A.P.
Date:

FIGURE H-18



STREAM GAGE STATIONS
NO. RECORDING GAGES
1 Dry Cr. At Academy
2 Dog Cr. Outlet & Diversion
3 Dry Cr. Outlet Channel
4 Little Dry Cr. Outlet Channel
5 Little Dry Cr Nr. Friant
6 Little Dry Cr. At Mouth Nr. Friant
STAFF GAGES
7 Redbank Cr. At Herndon Ave.
8 Redbank Cr. At Shaw Ave.
9 Redbank Cr. At De Wolf Ave.
10 Fancher Cr. At Friant Kern Canal
PROJECT FEATURES
LETTER DESCRIPTION
A Alluvial Drain Detention Basin
B Big Dry Cr. Dam & Res. Enlargement
D Dog Cr. Diversion Enlargement
F Fancher Cr. Dam
P Pup Cr. Detention Basin
R Redbank Cr. Detention Basin
LEGEND
Project Area Boundary
State Highway
Railroad
Perennial Stream
Intermittent Stream
Ditch or Canal
Dike
Reservoir or Lake
Project Feature
Stream Gage
VICINITY MAP
OREGON
REDDING
SACRAMENTO
SAN FRANCISCO
FRESNO
NEVADA
CALIFORNIA
STUDY AREA
SCALE IN MILES
MILLERTON LAKE
FRIANT DAM
BIG DRY CR. DAM
REDBANK DAM
CLOVIS
FRESNO
SAN JOAQUIN RIVER
KINGS RIVER
37°00'
36°55'
36°50'
36°45'
119°50'
119°45'
119°40'
119°35'
119°30'
119°25'
SCALE
(Miles)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
REDBANK AND FANCHER CREEKS, CALIFORNIA
GENERAL PROJECT AREA
SCALE AS SHOWN
H1
112
SJ-11-20-11
CHIEF, HYDROLOGY SECTION



Area Shown on Subarea Map #1
Area Shown on Subarea Map #2
MILLERTON LAKE
FRIANT DAM
BIG DRY CR. DAM
REDBANK DAM
FRESNO
CLOVIS
SAN JOAQUIN RIVER
37°00'
36°55'
36°50'
36°45'
119°50'
119°45'
119°40'
119°35'
119°30'
Behymer A.
De Wolf A.
Tollhouse Road
Shepherd Ave
Herndon
Shaw Avenue
McKinley Avenue
Whites Bridge Road
Houghton
Ventura
Copper Avenue
Madsen Ave
Academy Avenue
Temperance Avenue
Clovis Avenue
De Wolf Ave
AT&SFRR
SPRR
Friant Canal
Alluvial Drain
Enterprise
Gould Canal
Mill Ditch
Fresno Canal
Wasteway
Outlet Channel
SCALE
(Miles)


RIVER
N
DEPARTME
SACRAMENTO DIST
SACRAME
REDBANK AND FANCHER CREEK
R C F
C A P
SUBAREA IN
SCALE: AS SH
H2
113
S
1/22/5
CHIEF, HYDROLOGY SECTION

LIST OF SUBAREA BY MAJOR DRAINAGE BASIN IN ALPHABETIC ORDER		
PROJECT OUTFLOW CHANNEL	SUBAREA NUMBER	DRAINAGE AREA (sq.mi.)
ALLUVIAL DRAIN	122730	2.65
DOG CREEK	130720	1.84
	132430	0.81
	132440	2.49
	222820	0.84
	230710	0.53
	230820	3.55
DRY CREEK	121130	0.70
	121230	0.54
	122220	3.30
	122221	3.03
	122810	0.60
	212140	14.90
	220730	7.77
	221530	44.00
	221810	0.38
	222020	1.46
	222030	5.60
ENTERPRISE CANAL	123531	2.00
	231331	0.82
	231430	0.50
	231820	0.47
	332020	1.00
	332710	1.34
	332730	1.02
FANCHER CREEK	222640	1.88
	223540	2.05
	230210	3.05
	231220	20.87
	231330	0.80
	232620	0.82
	233430	0.36
FRESNO CANAL	233110	2.95
	233430	0.99
GOULD CANAL	232541	1.02
	232630	2.38
	232710	1.57
	232910	2.93
	233010	0.78
LITTLE DRY CREEK DIVERSION CHANNEL	120320	0.33
	120330	0.16
	120340	1.14
	120920	2.76
	121120	0.11
MILL DITCH	132530	1.95
MUD CREEK	232540	0.39
	331730	6.16
	331920	0.70
PUP CREEK	123530	1.06
	130120	1.12
	130130	0.54
	130230	1.05
	223030	0.49
REDBANK CREEK	132640	0.83
	222730	0.86
	222840	0.78
	223410	1.13
	223530	0.20
	230840	1.17
	230940	5.12
	231030	0.44
	231510	1.04
	231610	0.30
	231640	0.29
	231930	1.74
	231940	1.21

LEGEND

Project Area Boundary

Subarea Boundary

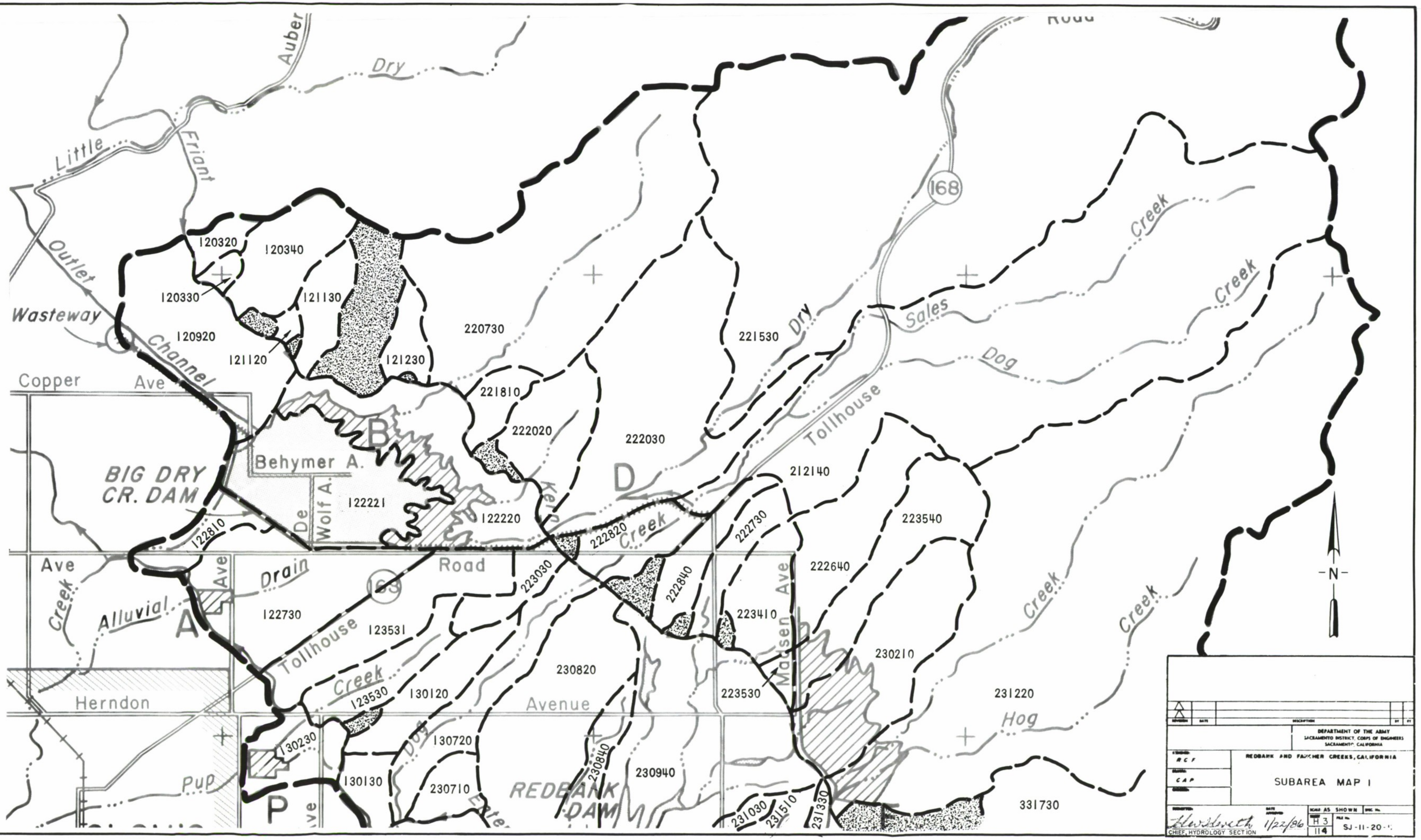
212140 Subarea Number

Non Contributing Area

SCALE

1 0 1

(Miles)



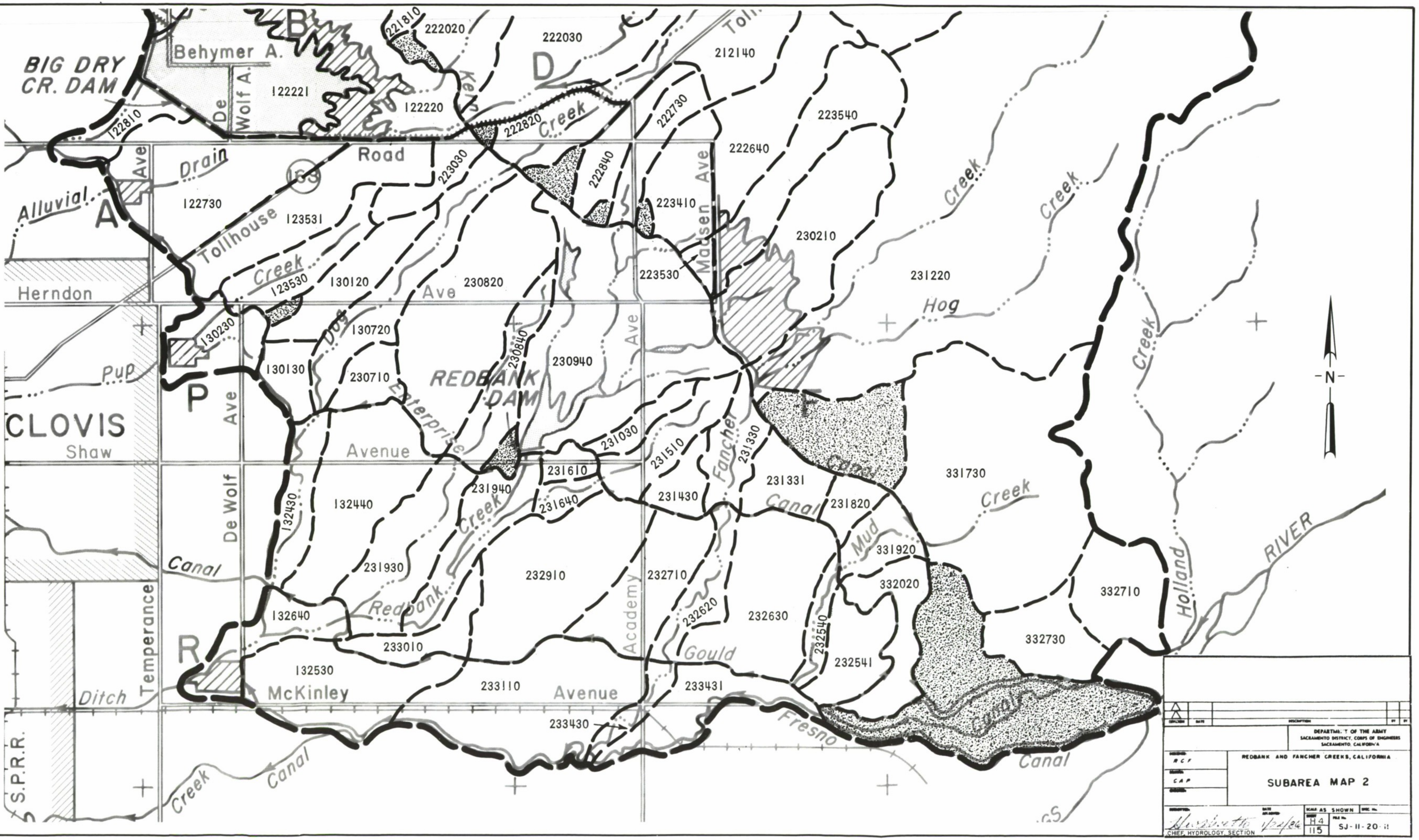
LIST OF SUBAREA
BY MAJOR DRAINAGE BASIN IN
NUMERICAL ORDER

SUBAREA NUMBER	PROJECT OUTFLOW CHANNEL	DRAINAGE AREA (sq.mi.)
120320	LTL. DRY CR. DIV. CHAN.	0.33
120330	LTL. DRY CR. DIV. CHAN.	0.16
120340	LTL. DRY CR. DIV. CHAN.	1.14
120920	LTL. DRY CR. DIV. CHAN.	2.76
121120	LTL. DRY CR. DIV. CHAN.	0.11
121130	DRY CREEK	0.70
121230	DRY CREEK	0.54
122220	DRY CREEK	3.30
122221	DRY CREEK	3.03
122730	ALLUVIAL DRAIN	2.65
122810	DRY CREEK	0.60
123530	PUP CREEK	1.06
123531	ENTERPRISE CANAL	2.00
130120	PUP CREEK	1.12
130130	PUP CREEK	0.54
130230	PUP CREEK	1.05
130720	DOG CREEK	1.84
132430	DOG CREEK	0.81
132440	DOG CREEK	2.49
132530	MILL DITCH	1.95
132640	REDBANK CREEK	0.83
212140	DOG CREEK TO DRY CREEK	14.90
220730	DRY CREEK	7.77
221530	DRY CREEK	44.00
221810	DRY CREEK	0.38
222020	DRY CREEK	1.46
222030	DRY CREEK	5.60
222640	FANCHER CREEK	1.88
222730	REDBANK CREEK	0.86
222820	DOG CREEK	0.84
222840	REDBANK CREEK	0.78
223030	PUP CREEK	0.49
223410	REDBANK CREEK	1.13
223530	REDBANK CREEK	0.20
223540	FANCHER CREEK	2.05
230210	FANCHER CREEK	3.05
230710	DOG CREEK	0.53
230820	DOG CREEK	3.55
230840	REDBANK CREEK	1.17
230940	REDBANK CREEK	5.12
231030	REDBANK CREEK	0.44
231220	FANCHER CREEK	20.87
231330	FANCHER CREEK	0.80
231331	ENTERPRISE CANAL	0.82
231430	ENTERPRISE CANAL	0.50
231510	REDBANK CREEK	1.04
231610	REDBANK CREEK	0.30
231640	REDBANK CREEK	0.29
231820	ENTERPRISE CANAL	0.47
231930	REDBANK CREEK	1.74
231940	REDBANK CREEK	1.21
232540	MUD CREEK	0.39
232541	GOULD CANAL	1.02
232620	FANCHER CREEK	0.82
232630	GOULD CANAL	2.38
232710	GOULD CANAL	1.57
232910	GOULD CANAL	2.93
233010	GOULD CANAL	0.78
233110	FRESNO CANAL	2.95
233430	FANCHER CREEK	0.36
233431	FRESNO CANAL	0.99
331730	MUD CREEK	6.16
331920	MUD CREEK	0.70
332020	ENTERPRISE CANAL	1.00
332710	ENTERPRISE CANAL	1.34
332730	ENTERPRISE CANAL	1.02

LEGEND

Project Area Boundary
Subarea Boundary
331730 Subarea Number
Non Contributing Area

SCALE
0
(Miles)



LEGEND:

- Natural Channels. } ARROW DENOTES FLOW DIRECTION
- Canals.
- Overland Flow.

B1 / A2 — Boundaries for Local Urban Drainage (Hydrographs from these areas are controlled by local flood control agencies).

233431 — Inflow Hydrograph and I.D. Number.

Existing Reservoirs.

Project Sites.

Diversion, or Routing Point

Flow Routed Under a Canal or Creek Through a Culvert or Siphon.

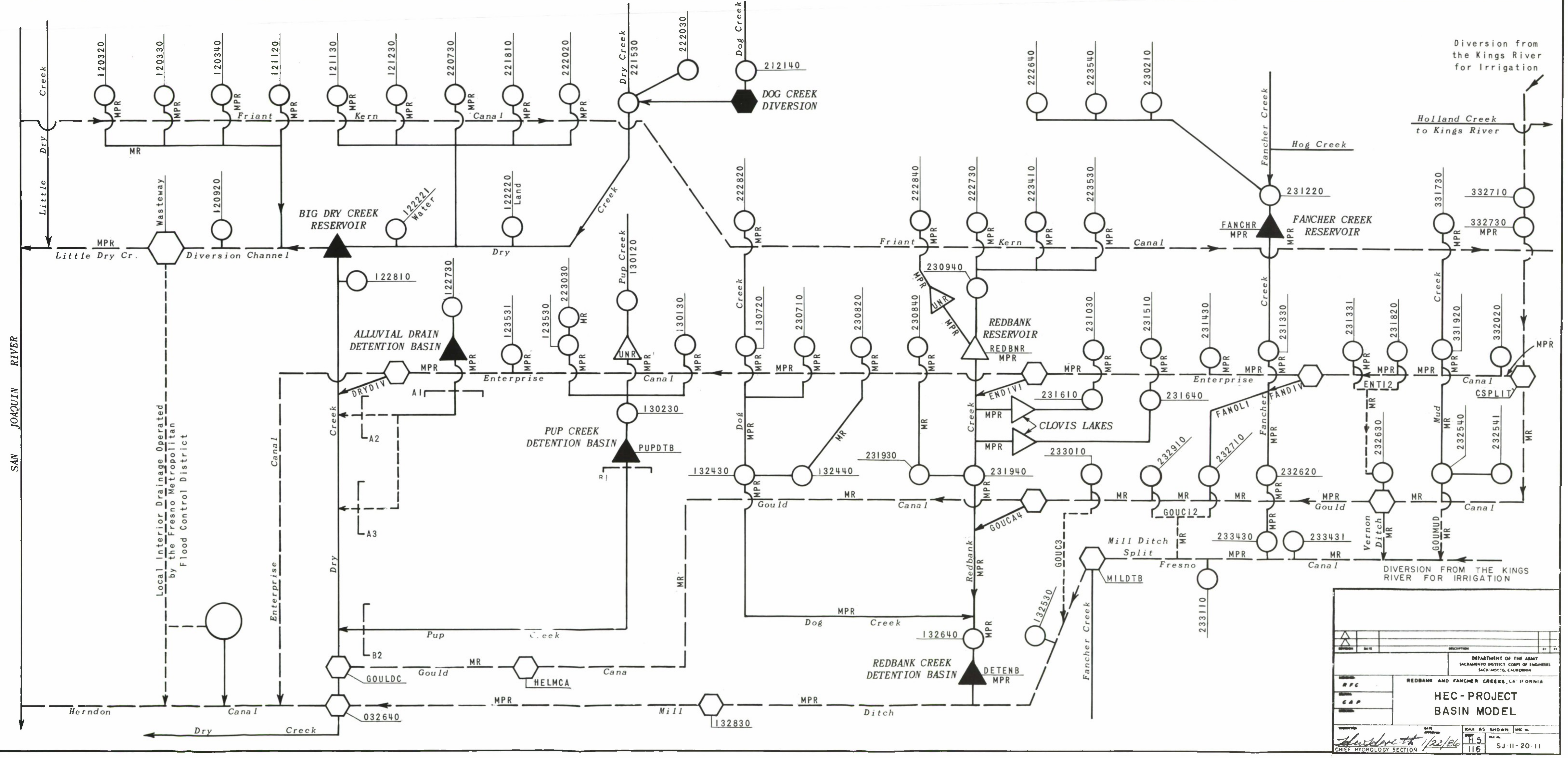
Flow Routed into and over an Open Channel.

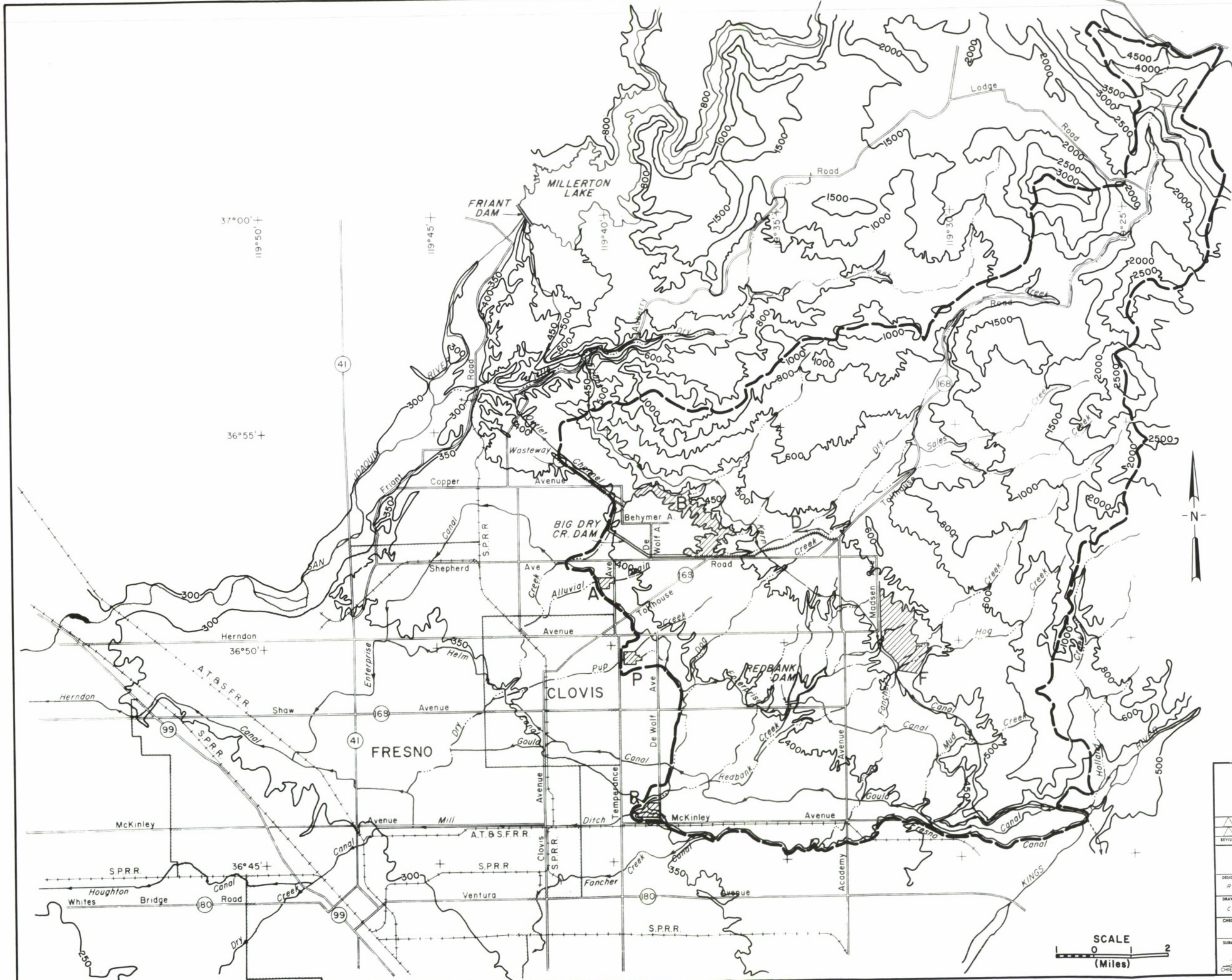
UNR — UnNamed Reservoir

MPR — Modified Puls Routing Between the two Adjacent Points or Through a Culvert.

MR — Muskingum Routing Between two Adjacent Points.

no notation — Hydrographs are Combined Directly Between two Adjacent Points if MPR or MR is not Present.





REVISION	DATE	DESCRIPTION	BY

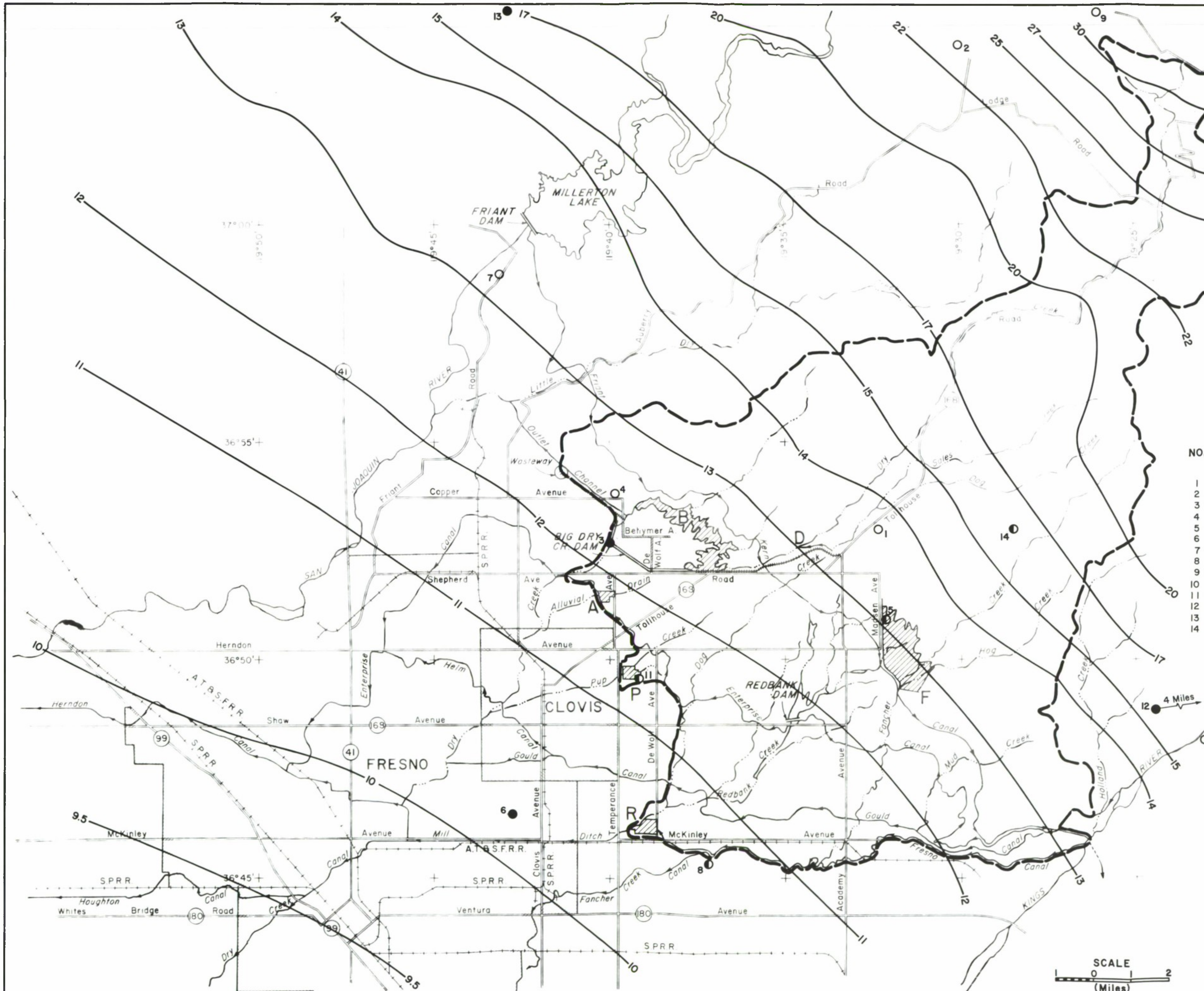
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DESIGNED: R F C
DRAWN: C A P
CHECKED:

REDBANK AND FANCHER CREEKS, CALIFORNIA

TOPGRAPHY

SUBMITTED: CHIEF, HYDROLOGY SECTION
DATE APPROVED:
SCALE: AS SHOWN
SPEC. No.
SHEET H 6 / 117
FILE No. SJ-11-20-11



PRECIPITATION STATIONS

NO.	NAME	ELEVATION (Ft.)	N.A.P. (In.)	PERIOD OF RECORD
1	Academy	545	13.8	1958-Date
2	Auberry INW	2140	23.8	1916-Date
3	Big Dry Cr. Res.	400	12.1	1948-Date
4	Clovis 7NE	404	12.3	1917-1947
5	*Fancher Creek	477	13.1	1982-Date
6	Fresno WSO AP	328	10.5	1878-Date
7	Friant Govt. Camp	410	13.7	1902-Date
8	*Limbaugh	360	10.7	1982-Date
9	Meadow Lake	4485	30.1	1948-1976
10	Piedra	580	16.4	1917-1964
11	*Pup Creek	383	11.3	1982-Date
12	Pine Flat Dam	610	18.1	1952-Date
13	San Joaquin Exp. Range	1050	17.7	1940-Date
14	*Watts Valley	920	16.1	1982-Date

*These stations were installed in late 1982 for temporary pre-project use. These locations may change upon completion of the project. Elevations and N.A.P. values for these stations were estimated from topographic and N.A.P. maps.

LEGEND

—20— NAP Isohyet amount in inches
● Recording
○ Non-Recording
◐ Temporary Recording Station

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

REDBANK AND FANCHER CREEKS, CALIFORNIA

NORMAL ANNUAL PERCIPITATION

DESIGNED: R F C
DRAWN: C A P
CHECKED:
SUBMITTED: CHIEF, HYDROLOGY SECTION
SCALE: AS SHOWN
SHEET 18
FILE No. SJ-11-20-11

RESERVOIR SEDIMENTATION FOR THE EAST SIDE RESERVOIRS IN THE SAN JOAQUIN RIVER BASIN

MAP NO.	RESERVOIR NAME[1]	LOCATION (STREAM. COUNTY)	DRAINAGE AREA FOR SEDIMENT[2] CONTRIBUTION (Sq. Mi.)	MEAN ANNUAL PRECIPITATION (Inches)	SURVEY PERIOD (Years)	AVG. ANNUAL SEDIMENT DEPOSITION RATE[3] (AF/Sq. Mi.)
1	Pardee	Mokelumne R. Amador Co.	387	46	14	0.15
2	Davis	Trib. Calaveras R. San Joaquin Co.	7.87	19	28	0.25
3	Gilmore	Trib. Mormon Sl. San Joaquin Co.	5.01	19	28	0.13
4	Don Pedro	Tuolumne R. Tuolumne Co.	996	42	23	0.21
5	La Grange	Tuolumne R. Stanislaus Co.	1,532	44	10	0.08
6	Exchequer	Merced R. Mariposa Co.	1,027	44	19	0.17
7	Crane Valley	N.F. Willow Cr. Madera Co.	54.5	47	45	0.16
8	Study Area Big Dry Creek	Dry Cr. Fresno Co.	78.6[4]	17.6	0	--
	Fancher Creek	Fancher Cr. Fresno Co.	27.9	14.9	0	--
9	me	Tenmile Cr. Fresno Co.	24.2	39	37	0.03
10	Pine Flat	Kings R. Fresno Co.	1,542	38	22	0.15

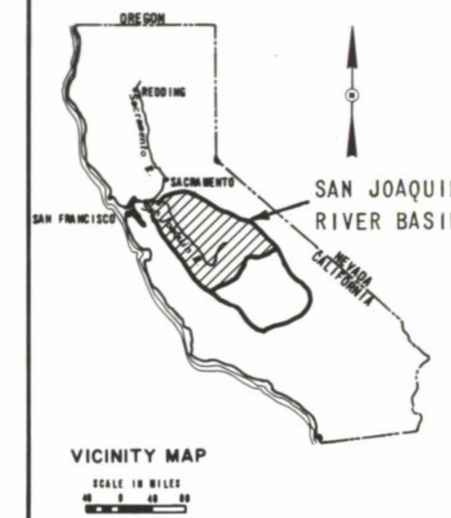
NOTES:

1/ Reservoirs are listed in orde from north to south, and on the same river from upstream to downstream.

2/ Drainage area excludes the drainage hove upstream reservoirs that prevent sediment from reaching downstream reservoirs.

3/ The average rate of sedimentation for the corded reservoirs is 0.15 acre-feet/square mile/year.

4/ This is Big Dry Creek Reservoir's contributing a .



Source:
"San Joaquin Valley Basin Study, California", SCS, Nov. 1977. "Sediment Deposition in U.S. Reservoirs - Summary of Data Report through 1980", USGS, May 1983.

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

R F C
C A P

BIG DRY CREEK AND FANCHER CREEKS, CALIFORNIA

RESERVOIR SEDIMENTATION

SCALE AS SHOWN
1/22/86
CHIEF, HYDROLOGY SECTION
SJ-11-20-11

REDBANK AND FANCHER CREEKS,
CALIFORNIA

APPENDIX B

ENVIRONMENTAL RESOURCES

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT
SACRMENTO, CALIFORNIA

APPENDIX B - ENVIRONMENTAL RESOURCES

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United States Department of the Interior

FISH AND WILDLIFE SERVICE

Division of Ecological Services
2800 Cottage Way, Room E-1803
Sacramento, California 95825

December 23, 1985

District Engineer
Sacramento District, Corps of Engineers
650 Capitol Mall
Sacramento, California 95814

Subject: Redbank and Fancher Creeks Flood Control Project, Fresno County, California

Dear Sir:

This supersedes our detailed Fish and Wildlife Coordination Act report of October 14, 1976 on this project. It has been prepared under the authority, and in accordance with the provisions, of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. et seq.). It is for inclusion in your General Design Memorandum No. 1 being prepared for the project. Basic authority for the study is provided in resolutions adopted by the Committee on Public Works of the House of Representatives on June 13, 1956 and May 8, 1964.

Our recommendations are based on the U.S. Fish and Wildlife Service Mitigation Policy (Federal Register, Volume 46:15, January 23, 1981) which provides internal guidance for establishing appropriate compensation for projects under our purview. Under this policy, resources are divided into four categories to assure that recommended compensation is consistent with the resources involved. These resource categories cover a range of habitat values from those considered to be unique and irreplaceable to those believed to be of relatively low value to fish and wildlife. In accordance with this policy, we have designated the riparian habitat in the project area as Resource Category 2. This habitat is extremely scarce in California and is of high value to a variety of wildlife. For this category the mitigation goal is no net loss of "in-kind" habitat value. Grasslands are considered as being in Resource Category 3. This habitat type is of medium to high value for wildlife species in the project area and is relatively abundant in the San Joaquin Valley. The mitigation goal is no net loss of habitat value while minimizing loss of "in-kind" habitat value. Agricultural lands in the project area are considered as being in Resource Category 4. The mitigation goal is to minimize loss of habitat value.

The recommendations presented in this report have the concurrence of the California Department of Fish and Game as indicated by the attached copy of

Director Jack C. Parnell's letter of December 5, 1985. Mr. Parnell does, however, make reference to the Department's letter (November 21, 1985) commenting on Design Memorandum Number 1 for the Redbank and Fancher Creeks Project. In that letter the Department made recommendations relating to natural revegetation, siltation removal, grazing and grasslands. We urge the Corps of Engineers to accommodate to the fullest extent possible those Department of Fish and Game recommendations that are not inconsistent with Federal guidelines and policy applicable to water resource development projects.

DESCRIPTION OF THE AREA

The project area is located on the east side of the San Joaquin Valley in the north-central portion of Fresno County (Plate I). All project features are located east of the Fresno-Clovis metropolitan area. The watershed covers about 175 square miles. The three major stream systems include Dry and Dog Creeks; Redbank, Fancher and Hog Creeks; and Pup Creek and the Alluvial Drain. These streams collect storm runoff from the foothills and convey the water down to the valley floor through the Fresno-Clovis metropolitan area to Fresno Slough, and finally into the San Joaquin River. Climate in the area is semi-arid with hot, dry summers and cool, moist winters. Rainfall in the valley floor and lower foothills varies between 12-15 inches annually, most of which falls from November through April. Population in the project area is about 120,000. Land use in the project area is mainly agricultural followed by residential and commercial developments.

DESCRIPTION OF THE PROJECT

The primary project features include enlargement of an existing dam, construction of one new dam, and construction of three new detention basins (Table 1).

Table 1. Project Features, Redbank and Fancher Creeks

	Capacity(Gross Pool acre-feet)		Area (Acres)	
Dam	Existing	Proposed	Existing	Proposed
Big Dry Creek	16,500	31,785	1,530	2,212
Fancher Creek		9,708		1,351
Detention Basin				
Red Bank		940		168
Pup Creek		495		63
Alluvial Drain		385		57

The project features have been designed to control damaging flood flows in the Fresno-Clovis metropolitan area and the surrounding rural and agricultural lands, from a 200-year flood. The enlarged Big Dry Creek Dam will essentially eliminate flooding on about 11,100 acres. Fancher Creek Dam and Redbank Detention Dam will protect 26,300 acres of agricultural-

urban lands, and Pup Creek and Alluvial Drain will reduce flooding on 500 acres. Total flood protection will be provided on about 37,900 acres of land.

EXISTING CONDITIONS

Vegetation

The project area lies in the valley-grassland community which includes grasses such as brome, foxtail, wild oat, needlegrass, weeds and forbs. Woody riparian vegetation, including cottonwood, willow and sycamore trees plus shrubs and vines, occurs in scattered areas along stream courses. Grasslands are used primarily for grazing while agricultural crops consist of barley, cotton, grape and peach. Habitat types within the reservoir areas and detention basins are shown in Table 2.

Table 2. Habitat types within the reservoirs and detention basins, Redbank and Fancher Creeks.

	Water	Grassland	Agricultural	Riparian	Total
Big Dry Creek	44	2,099	34	35	2,212
Fancher Creek	--	1,271	80	Negl.	1,351
Pup Creek	--	63	--	--	63
Alluvian Drain	--	57	--	--	57
Redbank	--	125	43	--	168

Fish

Streams and drains in the project area are intermittent and support low populations of warmwater species of fish such as bluegill, green sunfish, largemouth bass, western sucker, hitch and brown bullhead. Usually there is a carryover population of fish in Big Dry Creek Reservoir. However, there is no public access and fishing use is low.

Wildlife

Wildlife resources include a variety of songbirds, water-associated birds, small mammals, amphibians, and reptiles. Typical grassland species include meadowlark, horned lark, sparrows, raptors, black-tailed jackrabbit, striped skunk, coyote, badger and small rodents. Except within the pool area in Big Dry Creek Reservoir, riparian habitat only exists in scattered patches along creeks and drains. Riparian habitat provides nesting and feeding habitat for a variety of songbirds as well as cover for small mammals such as raccoon, striped skunk, and gray fox. Raptors also nest and roost in the larger trees. Vegetation along the ditches and fence rows in the project area provide habitat for ring-necked pheasant, California quail, mourning dove, and desert cottontail. Most of the land is privately-owned, and little public hunting occurs. Little, if any trapping for furbearers occurs. Waterfowl use Big Dry Creek Reservoir for resting and feeding during migrations. Hunting use is limited and low.

Endangered Species

In response to a Corps of Engineers request for a list of endangered and threatened species, the Fish and Wildlife Service advised by letter of March 9, 1982 that no listed or proposed species are believed to occur in the project area. In view of the elapsed time, the Corps should recontact the Service's Sacramento Office of Endangered Species prior to initiation of any construction work, to ascertain if the 1982 advice is still correct.

WITHOUT THE PROJECT

Fish and Wildlife

Conditions for fish resources are not expected to change significantly in the future. Some encroachment of residential developments in the grassland areas is expected. This will result in a reduction of wildlife populations dependent upon this habitat.

WITH THE PROJECT

Fish

The project will have little impact on fish resources in the project area. Except for the residual pool in Big Ory Creek Reservoir, there will be no permanent pools in Fancher Creek Reservoir or the detention basins. Normal stream flows will continue to flow through the reservoirs unregulated. Flood flows will be temporarily impounded and released at rates designed to prevent flooding downstream lands.

Wildlife

Construction of the project will result in some adverse impacts to wildlife habitat. Construction of embankments and excavation in the borrow areas and detention basins will result in a loss of about 1,700 acres of grassland habitat. This will result in a loss of grassland habitat value for ground nesting birds such as the horned lark, meadowlark, sparrows, small rodents, reptiles, and foraging areas for raptors, coyote and fox. Reseeding the embankments and borrow areas with grasses of high value to wildlife will offset this loss within one or two years following project construction. Some additional grassland habitat will be adversely impacted when flood waters are temporarily stored in the reservoirs and detention basins. The 35 acres of riparian habitat in Big Dry Creek Reservoir will not be affected.

OISCUSSION

Construction of the project will have a temporary adverse impact on fish and wildlife resources in the project area. There will be a two-year loss of 1,700 acres of grassland habitat during project construction of two dams and three detention basins. Habitat values should recover in about two years following reseeding of the embankments and borrow areas.

The Service's Habitat Evaluation Procedures (HEP) were not employed as a basis to develop compensation because: (1) riparian habitat will not be impacted and thus there is no need for compensation measures, and (2) although about 1,700 acres will be disturbed during project construction, habitat values will recover in about two years following reseeding and natural revegetation of grasses in the areas.

Impacts of project construction on grassland habitat can be offset by planting species of high wildlife habitat value on the embankments of Big Dry Creek Dam and Fancher Creek Dam, borrow areas, and detention basins. Plant species should include a 50-50 percent of mix of Perla grass, Phalaris tuberosa var. hirtiglumis, and lana vetch, Vicia dasycarpa. These plants can be hydroseeded as part of the Corps' normal revegetation plan for the project. These plants will provide food and cover for a variety of wildlife species such as mourning dove, pheasant, quail and rabbit. It would also be beneficial if quailbush, Atriplex lentiformis could be interspersed at 30-foot intervals on the embankments and four-winged salt bush, Atriplex canescens planted in borrow areas.

Agricultural lands consist of about 160 acres of orchards and grapes in the pool areas, some of which will be retained. This habitat is of low to medium value for wildlife species and is considered as being in Resource Category 4. Impacts of project construction on wildlife using these lands will be insignificant. Preservation of habitat in the flood pool areas as open space will have a beneficial effect by preventing urban encroachment into agricultural and grassland areas. Conversely, protection of these habitats in the flood plain also may accelerate urban development.

RECOMMENDATIONS

We recommend:

1. That the report of the District Engineer, Corps of Engineers, include the conservation and development of fish and wildlife resources among the purposes for which the project is to be authorized.

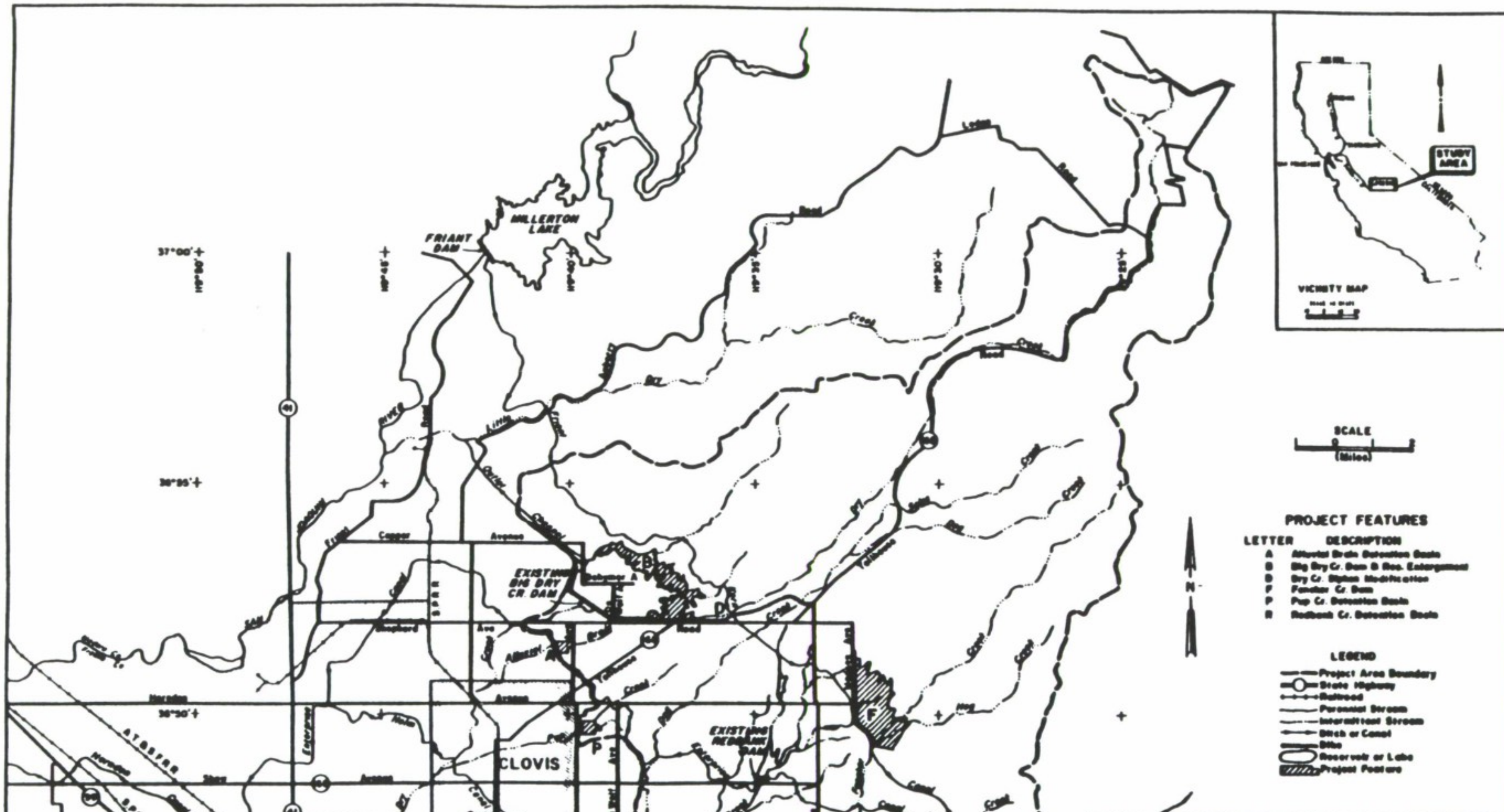
2. That embankments and borrow areas and detention basins be planted with plant species described in the Discussion section. Costs for revegetation should be a project cost. Planting should be coordinated with the California Department of Fish and Game and the U.S. Fish and Wildlife Service.

Please notify us of your proposed action regarding these recommendations.

Sincerely,

James D. Carson

James D. Carson
Acting Field Supervisor



UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE

GENERAL MAP
CORPS OF ENGINEERS

REDBANK AND FANCHER CREEKS
FLOOD CONTROL PROJECT
Fresno County, California

November 1985 Sacramento, Calif.
Plate 1.

STATE OF CALIFORNIA—THE RESOURCES AGENCY

GEORGE DEUKMEJIAN, Governor

DEPARTMENT OF FISH AND GAME
1416 NINTH STREET
SACRAMENTO, CALIFORNIA 95814
(916) 445-3531

December 5, 1985

James J. McKevitt
Field Supervisor
Fish and Wildlife Service
Division of Ecological Services
2800 Cottage Way, Room E-1803
Sacramento, CA 95825

Subject: U.S. Army Corps of Engineers - Redbank and Fancher Creeks Flood Control Project, Fresno County, California Draft Fish and Wildlife Coordination Act Report

Dear Mr. McKevitt:

We have reviewed your draft Fish and Wildlife Coordination Act Report for the Corps' Redbank and Fancher Creeks Flood Control Project. Our Department concurs with the recommendations presented in your report.

Enclosed is a copy of our comments on the project's Design Memorandum Number 1. In addition to on-site impacts, we have considered the off-site impacts that will occur as a direct result of the proposed flood control features. We have also considered the impacts of future operations and maintenance activities on wildlife habitat (grazing, dredging). Consequently, we call for more extensive compensatory features than provided for in your report. We recommend that you consider adding these additional items in the Final Coordination Act Report.

We appreciate this opportunity to review and comment on your report. If we can be of further assistance, please contact George Nokes, Regional Manager, 1234 E. Shaw Avenue, Fresno, CA 93710, phone (209) 222-3761.

Sincerely,

for Jack C. Parnell
Director

Enclosures

DEPARTMENT OF FISH AND GAME

REGION 4
1234 E. Shaw Avenue
Fresno, CA 93710
(209) 222-3761

November 21, 1985

George C. Weddell, Chief
Engineering Division
Department of the Army
Sacramento District
Corps of Engineers
650 Capitol Mall
Sacramento, CA 95814

Subject: Draft Design Memorandum Number 1
Redbank and Fancher Creeks

Dear Mr. Weddell:

We have reviewed the Draft Design Memorandum Number 1 for the Redbank and Fancher Creeks Project. We note that the project, as therein described, has been substantially revised since the FEIS was accepted in 1980. Our prior comments pertained to that original description and therefore also will require revision in order to be applied to the current project.

Originally, we identified wildlife habitat reduction as an important adverse effect of the project. The habitat loss included on-site direct damage as well as off-site indirect effects (of increased development on project flood-protected lands). The original project did not compensate for the indirect habitat losses, however, on-site compensation was provided for habitat directly impaired by the project. This compensation habitat was closely associated with the (then) proposed 500-acre recreational pool at Big Dry Creek Reservoir. Since that time, the recreational pool has been deleted from the project. We are unable to determine whether the compensation habitat has likewise been deleted. We would object to such deletion since the reduced project would still cause significant habitat losses.

We offer the following recommendations for measures to lessen or compensate habitat losses caused by the project:

1. Include in the design of each project element, allowances for <u>unmaintained</u> natural revegetation. Water conveyances should be adequately sized to contain design flows, along with allowed revegetation. Periodic clearing should not be practiced inside the compensation habitat allowance areas.

2. Project features should include allowances in design that will permit required siltation removal in phases.

3. Grazing should be completely eliminated from all project lands to permit their utilization by wildlife and to allow the potential for the reestablishment of native plant species.

4. The 90-acre area that the FEIS stated was to be converted to riparian habitat should be retained as a project habitat compensation feature.

5. Wherever practicable, revegetation of grasslands with native plant species should be required.

The above constitute our comments and recommendations regarding the project as currently planned. We appreciate the opportunity to review this document. Inquiries regarding these comments should be directed to Michael Mulligan at the letterhead address and telephone.

Sincerely,

George Nokes

George D. Nokes
Regional Manager

cc: Lauren Renning, Corps of Engineers

United States Department of the Interior

FISH AND WILDLIFE SERVICE
AREA OFFICE
2800 Cottage Way, Room E-2740
Sacramento, California 95825

[illegible] 1982

In reply refer to: SESO
#1-1-82-SP-177

Mr. George C. Weddell
Chief, Engineering Division
Department of the Army
Sacramento District
Corps of Engineers
650 Capitol Mall
Sacramento, California 95814

Subject: Request for List of Endangered and Threatened Species in the Area of Redbank and Fancher Creeks, Fresno County, California

Dear Mr. Weddell:

This is in reply to your letter of February 23, 1982, requesting a list of listed and proposed endangered and threatened species that may occur within the area of the subject project. Your request and this response are made pursuant to Section 7(c) of the Endangered Species Act of 1973 as amended (PL 95-632).

We have reviewed the most recent information and to the best of our knowledge there are no listed or proposed species within the area of the project. We appreciate your concern for endangered species and look forward to continued coordination. If you have further questions, please contact Mr. Swanson of our Endangered Species Field Office at (FTS) 448-2791 or (916) 440-2791.

Sincerely,

Area Manager

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
650 CAPITOL MALL
SACRAMENTO, CALIFORNIA 95814

REPLY TO
ATTENTION OF

January 23, 1986

Environmental Resources Branch

Mr. James J. McKevitt
Field Supervisor
U.S. Department of Interior
Fish and Wildlife Service
Division of Ecological Services
2800 Cottage Way, RM E-1803
Sacramento, California 95828

Dear Mr. McKevitt

This responds to the recommendations contained in your December 23, 1985 Coordination Act Report for the Redbank and Fancher Creeks project. We concur with your recommendation No. 2 and will continue to coordinate revegetation plans with the California Department of Fish and Game, the U.S. Soil Conservation Service, and with your office to insure that impacted areas are planted with native plants.

We are unable to concur with recommendation No. 1, that conservation and development of fish and wildlife resources be included among the purposes for which the project is to be authorized. There will be no specific added enhancement for fish and wildlife. No project costs are allocated to fish and wildlife purposes. These are the criteria which must be met before we can recommend fish and wildlife resource development as a project purpose.

As suggested in your report, we have evaluated the recommendations relating to natural revegetation, siltation removal, and grazing and grasslands, made by the California Department of Fish and Game's (DFG) letter (November 21, 1986), and will accommodate them to the fullest extent possible. I am enclosing a copy of our letter to DFG for your information. If your have any question concerning the above, please contact Ms. Lauren Renning at (916) 551-2085.

Sincerely,

Daryl Salladay

for Walter Yep
Chief, Planning Division

Enclosure

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
650 CAPITOL MALL
SACRAMENTO, CALIFORNIA 95814

REPLY TO
ATTENTION OF

January 24, 1986

Environmental Resources Branch

Mr. George D. Nokes, Regional Manager
Department of Fish and Game
1234 E. Shaw Avenue
Fresno, California 93710

Dear Mr. Nokes

This responds to your letter of November 21, 1985 suggesting five fish and wildlife measures for the Redbank and Fancher Creeks project at Fresno, California. We believe four of your five suggestions can be implemented or assisted as explained below.

1. Vegetation allowance in channel design. - We will be pleased to discuss with you and the project sponsor, Fresno Metropolitan Flood Control District, the degree to which vegetation can be allowed inthe channels downstream from the five dams/detention basins to be constructed or modified by the Corps of Engineers. During more detailed design we will evaluate the extent, if any, vegetation can be allowed and still maintain the necessary channel capacities. The project authorization does not provide for Federal construction of channel improvement not directly associated with the outlet structures. It provides that the project sponsor preserve, restore and maintain the channels for conveyance of floodwaters to capacities described in the February 1986 General Design Memorandum. We will seek your views in discussions with the project sponsor as we prepare the operation and maintenance manual for the channels.

2. Phased sediment removal in design of project features. - We understand that the purpose of this is to allow vegetation to accumulate undisturbed at sediment sites for as long as practicable and to avoid sediment removal over wide areas when removal is required. We concur that sediment removal can be phased since we expect relatively low sedimentation rates. We will seek your views on this aspect of the operation and maintenance manual also.

3. Eliminate grazing from all project lands to benefit wildlife and native plants. - We will be pleased to discuss this aspect with you and the project sponsor to determine the extent to which

this may be practicable. The sponsor will acquire all necessary lands interest and this may be in easements or in fee title. The interest to be acquired in lands over and above flood control needs for the needs you suggest will be a decision of the project sponsor.

4. Retain the 90-acre riparian habitat feature described in the FEIS. - This is the suggestion we cannot concur with. This feature was only required to mitigate losses attributed to flooding from the recreation pool. Since the recreation pool has been eliminated, the losses will not occur and this mitigation feature is not needed. However, this suggestion may be able to be implemented as part of the previous suggestion, to the extent that this is found possible.

5. Revegetate with native plant species. - This is similar to the recommendation of the U.S. Fish and Wildlife Service in which we concur, that project construction areas be replanted, and we concur that native plants will be used.

Our project engineer, Lauren Renning will be available to participate in discussions with you and the project sponsor. Please contact her at (916) 551-2085 if you have any questions or would like to schedule a meeting.

Sincerely,

Daryl Salladay

for Walter Yep
Chief, Planning Division

Copy Furnished:

U.S. Fish and Wildlife Service, 2800 Cottage Way, Sacramento, California 95814

REDBANK AND FANCHER CREEKS,
CALIFORNIA

APPENDIX C

PRELIMINARY DRAFT COOPERATIVE AGREEMENT

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT
SACRMENTO, CALIFORNIA

PRELIMINARY
DRAFT
AGREEMENT BETWEEN
THE UNITED STATES OF AMERICA
AND
THE FRESNO METROPOLITAN FLOOD CONTROL DISTRICT
FOR
THE REDBANK AND FANCHER CREEKS, CALIFORNIA, FLOOD CONTROL PROJECT

THIS AGREEMENT, entered into this ____________ day, of ___________, 19__, by and between the UNITED STATES OF AMERICA (hereinafter called the "GOVERNMENT"), represented by the Contracting Officer executing this Agreement, and the Fresno Metropolitan Flood Control District (hereinafter called the "Sponsor").

WITNESSETH, that

WHEREAS, construction of the Redbank and Fancher Creeks, California, Flood Control Project (hereinafter called the "Project") was authorized by the ______________________________________, in accordance with the recommendations of the Chief of Engineers in his Report dated 7 May 1981 as amended by the 17 November 1983 recommendations of the Assistant Secretary of Army for Civil Works; and

WHEREAS, a General Design Memorandum dated ____________ for the Project was approved by the Chief of Engineers on ______________, and is the substantial basis for all subsequent design and construction of the Project, subject to changes and modifications deemed appropriate by the Government; and

WHEREAS, the parties hereto represent that they will each faithfully perform the obligations ascribed to each as set out in the 7 May 1981 Report of the Chief of Engineers, as amended by the 17 November 1983 recommendations of the Assistant Secretary of the Army for Civil Works, as updated in the General Design Memorandum, dated _____________, approved by the Chief of Engineers on _______________; and

WHEREAS, the Sponsor has the authority and capability to furnish the non-Federal cooperation set out in the said Report of the Chief of Engineers and General Design Memorandum as authorized in accordance with Federal legislation authorizing the Project and by other applicable laws, and to faithfully perform the terms of this agreement; and

WHEREAS, the Sponsor, as evidenced by letter dated _____________, agreed to a modification of the cost-sharing scheme set forth in the aforementioned legislation, Report of the Chief of Engineers and General Design Memorandum, whereby it would pay not less than a 25% share (which includes a mandatory 5% cash contribution) of the total Project costs through the provision of a combination of lands, easements, and rights-of-way, alterations and relocations, and direct cash contributions; and

WHEREAS, the Secretary of the Army pursuant to the War Department Civil Appropriation Act of 1938, adopted July 19, 1937 (50 Stat. 518; 33 USC 701h)

is authorized to receive and expend cash contributions tendered by the Sponsor for authorized flood control work;

WHEREAS, the Sponsor considers it in its best interest and proposes to pay not less than 25% of the total Project costs:

NOW THEREFORE, in consideration of the foregoing and the benefits which shall accrue to the Sponsor by construction of the Project, the parties agree as follows:

ARTICLE 1 - CONSIDERATION AND PAYMENT

a. The Sponsor will pay not less than 25% of the total project costs. Of the total project costs, a minimum of 5% shall be furnished as a mandatory cash contribution. The remaining local contribution shall be provided thru a combination of all lands, easements, rights-of-way, alterations and relocations, and, if necessary, additional cash contributions, as further specified in this agreement.

b. Total Project costs are costs applicable to the Project incurred by the Sponsor and Government subsequent to authorization of the Project (excluding betterments and operation and maintenance costs). Such total Project costs will include, but not necessarily be limited to, actual construction costs; acquisition expense for lands, easements and rights-of-way; relocation and alteration costs; costs of applicable engineering and design; and supervision and administration costs.

c. The Sponsor shall receive a credit against its share of total Project costs equal to the value of lands, easements and rights-of-way furnished pursuant to Article 3a hereof, including actual and reasonable supervisory, professional and administrative expenses incurred therewith. The amount to be credited to the Sponsor shall be established and agreed to as set forth in Article 4a hereof.

d. The Sponsor shall receive a credit against its share of total Project costs equal to the cost of relocations or alterations borne by it pursuant to Article 3b hereof, including actual and reasonable supervisory, professional and administrative expenses incurred therewith. The amount of credit will be established in accordance with the provisions of Article 4b hereof.

e. The Government, using funds contributed by the Sponsor and appropriated by the Congress, shall expeditiously construct the Project, applying those procedures usually followed or applied in Federal projects, pursuant to Federal laws, regulations and policies. Award of the contracts and performance of the work thereunder shall be exclusively within the control of the Government.

f. The Sponsor shall not have any recourse for reimbursement of any nature whatsoever from the Government for direct cash contributions of funds provided pursuant to this agreement (except within respect to excess cash contributions as set forth in Article 2f hereof).

ARTICLE 2 - METHOD OF PAYMENT

a. To provide for consistent and effective communication between the Sponsor and Government during the term of construction, the Sponsor and the Government will appoint representatives to coordinate on scheduling, plans, specifications, contract costs and other matters relating to construction of the Project.

b. At least six months before each Sponsor fiscal year, the Government will make allowances for credits for lands, easements, rights-of-way, relocations and alterations and will notify the Sponsor of the estimated funds that will be required from the Sponsor to meet its share of total Projects costs for the corresponding Government fiscal year. The Sponsor will then make those funds available to the Government as expeditiously as possible through either cash payments or deposit of cash in an escrow account acceptable to the Government, or by irrevocable letter of credit drawn upon a bank acceptable to the Government. The Government estimate of the Sponsor's share of the total Project costs will include an amount for Government costs incurred prior to the date of this agreement. Government costs incurred to date are ________________, 25% of which will be repaid in _______ equal annual installments during the term of construction, as follows: (specify dates) ____

c. Forty calendar days prior to advertisement of a construction contract, the Government will make allowances for credits for lands, easements, rights-of-way, alterations and relocations and notify the Sponsor of its required share of contract costs, plus supervisory and administrative costs. Within 10 calendar days thereafter, the Sponsor will confirm to the satisfaction of the Government that sufficient funds are available to the Government in the funding institution or mechanism referred to in Article 2b to meet the Sponsor's share of contract costs for the Government fiscal year. If sufficient funds are not available to the Government through the funding institution or mechanism referred to in Article 2b above, the Sponsor shall deposit those funds within 10 calendar days and provide verification of such deposit. If a contract is expected to extend into more than one Government fiscal year, the Sponsor may make the deposits in installments, with each installment to be made prior to each Government fiscal year in the amount required for that year's work on the contract, plus supervisory and administrative costs, after allowances are made for credits for lands, easements, rights-of-way, alterations and relocations.

d. When bids are opened on any given contract and additional funds are needed from the Sponsor toward its share of total Project costs, the Sponsor agrees to deposit the additional funds within 10 calendar days after demand by the Government.

e. The Government will draw on the escrow account or letter of credit such sums as it deems necessary to cover contractual and in-house obligations as they occur and to cover the Sponsor's 25% share of costs incurred by the Government prior to the date of this agreement, as set forth in Article 2b.

f. Upon completion of the project and resolution of all contract claims and appeals, the Government will compute the total Project costs and

tender to the Sponsor a final accounting of its share of total Project costs. In the event the total Sponsor participation in the Project is less than 25% of total Project costs at the time of the final accounting, the Sponsor agrees to deposit within 30 calendar days after receipt of written notice, whatever sum is required to meet the minimum 25% share of total Project costs. In the event the Sponsor has tendered cash contributions in excess of the mandatory 5% and the Sponsor's total participation in the Project exceeds 25% of total Project costs, the Government will return to the Sponsor within 90 calendar days cash contributions which (1) exceed the mandatory 5% portion and (2) are in excess of 25% of total Project costs.

ARTICLE 3 - LANDS AND FACILITIES

a. The Sponsor will provide without cost to the United States all lands, easements, and rights-of-way necessary for construction, operation and maintenance of the Project.

b. The Sponsor will make and bear the cost of all relocations and alterations to existing improvements including highway facilities which may be required for construction of the Project.

c. The Sponsor will prescribe and enforce regulations to prevent obstruction or encroachment of any type that would impair the flood control effectiveness of project facilities, and will preserve, restore, and construct and thereafter maintain channels and diversion structures required for conveyance of floodwaters within the project area to at least those capacities as stated in the flood control system operation plan defined in the project General Design Memorandum dated ____________________.

d. The Sponsor will preserve, restore and thereafter maintain, at the capacities as stated in the flood control system operation plan defined in the project General Design Memorandum dated ____________________, the other multipurpose canals and channels of Fresno County which are within Project limits, but are not to be improved by the Project.

e. The Sponsor will provide guidance and leadership in preventing unwise future development of the floodplain by use of appropriate floodplain management techniques to reduce flood losses.

f. The Sponsor will at least annually, inform affected interests of the degree of protection provided by the Project.

g. The Sponsor will comply with the applicable provisions of the Uniform Relocations Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, approved January 2, 1971, in acquiring lands, easements and rights-of-way for construction and subsequent maintenance of the Project, and inform affected persons of pertinent benefits, policies and procedures in connection with said Act.

h. It is understood by the Parties hereto that all lands, easements and rights-of-way, as well as relocations and alterations of existing improvements, set out in paragraphs a and b above, will be furnished by the Sponsor to the Government at no cost to the Government notwithstanding any other provision of this agreement or the fact that the value of lands,

easements, rights-of-way, relocation or alteration of utilities and facilities could exceed 20% (25% - 5% mandatory minimum cash contribution) of total Project costs.

ARTICLE 4 - VALUE OF LANDS AND FACILITIES

a. The value of the lands, easements and rights-of-way to be credited toward the Sponsor's share of total Project costs, as covered in Article 1, shall be computed as follows:

(1) Credit for lands, easements and rights-of-way acquired by the Sponsor over lands not owned by the Sponsor as of the date of this agreement will be based on the amount actually paid to the owners of the lands, easements and rights-of-way and for any relocation assistance payments made in accordance with Article 3g hereof. Acquisition costs of lands, easements and rights-of-way will be supported by an appraisal to be obtained by the Sponsor and prepared by an independent and qualified appraiser who is mutually acceptable to the Sponsor and Government. Voluntary purchases exceeding the appraised value of the real estate interest to be acquired must be approved in advance by the Government. Credit for lands, easements and rights-of-way in the case of involuntary acquisitions will be based on court awards or stipulated settlements, in which instance the stipulated settlements must have prior Government approval.

(2) Credit for lands, easements and rights-of-way made available to the Government for lands already owned by the Sponsor, as of the date of this agreement, will be based on the fair market value of the lands, easements and rights-of-way at the time of this agreement and for any relocation assistance payments made in accordance with Article 3g hereof. Said fair market value will be established by an appraisal to be obtained by the Sponsor and prepared by an independent and qualified appraiser who is mutually acceptable to the Sponsor and Government.

(3) If the Sponsor acquires more lands, easements or rights-of-way than are necessary for Project purposes as determined by the Government, then only the value of such portion of said acquisitions as are necessary for Project purposes shall be included in total Project costs.

b. The cost of construction, relocation, alteration or modification of utilities or facilities to be credited toward the Sponsor's share of total Project costs, as covered in Article 1 hereof, will be supported by proof as to the actual costs incurred by the Sponsor for this work. For purposes of determining what portion of the costs of any such construction, relocation, alteration or modification shall be included in total Project costs, the following shall apply:

(1) Bridges and Highways: Only that portion of the costs as would be necessary to construct substitute bridges and roads to the design standard which the State of California and/or Fresno County would use in constructing a new bridge or road under similar conditions of geography and under similar traffic loads.

(2) Utility Facilities: The actual relocation cost, less depreciation, less salvage value, plus the cost of removal less the cost of

betterments. With respect to betterments, new materials will not be used in any relocation or alteration if materials of value and usability equal to those in the existing facility are available or can be obtained as salvage from the existing facility or otherwise, unless the provision of new material is more economical. If, despite the availability of used material, new material is used, where the use of such new material represents an additional cost, such costs will not be included in total Project costs.

ARTICLE 5 - DISPUTES

Any dispute arising under this agreement which is not disposed of by mutual consent shall be decided by the Contracting Officer who shall reduce his decision to writing and mail or otherwise furnish a copy thereof to the Sponsor. The decision of the Contracting Officer shall be final and conclusive unless, within 30 days from the date of receipt of such copy, the Sponsor mails or otherwise furnishes to the Contracting Officer a written appeal addressed to the Corps of Engineers Board of Contract Appeals. The decision of the Board shall be final and conclusive. Pending final decision of a dispute hereunder, the Sponsor shall proceed diligently with the performance of the agreement in accordance with the Contracting Officer's decision.

ARTICLE 6 - OPERATION AND MAINTENANCE

a. The Sponsor will operate and maintain the Project works upon Project completion in accordance with regulations prescribed by the Secretary of the Army.

b. The Sponsor hereby gives the Government a right to enter, at reasonable times and in a reasonable manner, upon land which it owns or controls for access to the project for the purpose of inspection, and for the purpose of completing, operating, repairing and maintaining the Project. If an inspection shows that the Sponsor for any reason is failing to complete, operate, repair, and maintain the Project in accordance with the assurances hereunder, the Government will send a written notice to the Sponsor. If the Sponsor has persisted in such failure for 30 calendar days after receipt of the notice, then the Government shall have a right to enter at reasonable times and in a reasonable manner, upon land the Sponsor owns or controls for access to the Project for the purpose of completing, operating, repairing or maintaining the Project. No completion, operation, repair or maintenance by the Government in such event shall operate to relieve the Sponsor of responsibility to meet its obligations as set forth in this agreement or to preclude the Government from pursuing any other remedy at law or equity to assure faithful performance pursuant to this agreement.

ARTICLE 7 - RELEASE OF CLAIMS

The Sponsor will hold and save the Government free from all damages arising from the construction and operation of the completed Project, except for damages due to the fault or negligence of the Government or its contractors.

ARTICLE 8 - MAINTENANCE OF RECORDS

The Government and the Sponsor shall keep books, records, documents and other evidence pertaining to costs and expenses incurred pursuant to this agreement to the extent and in such detail as will properly reflect total Project costs. The Government and the Sponsor shall maintain such books, records, documents and other evidence for a minimum three year period after completion of construction of the project, and shall make available at their offices at reasonable times, such books, records, documents and other evidence for inspection and audit by authorized representatives of the parties to this agreement.

ARTICLE 9 - FEDERAL AND STATE LAWS

a. In acting under its rights and obligations hereunder, the Sponsor agrees to comply with all applicable Federal and State laws and regulations.

b. The Sponsor agrees to comply with Section 601 of Title VI of the Civil Rights Act of 1964 (Public Law 88-532) and the Department of Defense Directive 5500.11 issued pursuant thereto and published in Part 300 of Title 32, Code of Federal Regulations in connection with the construction, operation, and maintenance of the Project.

ARTICLE 10 - RELATIONSHIP OF PARTIES

The parties to this agreement act in an independent capacity in the performance of their respective functions under this agreement, and neither party is to be considered the officer, agent or employee of the other.

ARTICLE 11 - OFFICIALS NOT TO BENEFIT

No member of or delegate to the Congress, or resident commissioner, shall be admitted to any share or part of this agreement, or to any benefit that may arise therefrom.

ARTICLE 12 - COVENANT AGAINST CONTINGENT FEES

The Sponsor warrants that no person or selling agency has been employed or retained to solicit or secure this agreement or understanding for a commission, percentage, brokerage, or contingent fee, excepting bona fide employees or bona fide established commercial or selling agencies maintained by the Sponsor for the purpose of securing business. For breach or violation of this warranty, the Government shall have the right to annul this agreement without liability or in its discretion to add to the agreement or consideration, or otherwise recover, the full amount of such commission, percentage, brokerage, or contingent fee.

IN WITNESS WHEREOF, the parties hereto have executed this agreement as of the day and year first above written.

THE UNITED STATES OF AMERICA

By ____________________

Colonel, Corps of Engineers
District Engineer
Contracting Officer

FOR THE SECRETARY OF THE ARMY

DATE: ____________________

FRESNO METROPOLITAN FLOOD CONTROL DISTRICT

By ____________________

ATTEST:

By ____________________
Counsel, Fresno Metropolitan Flood Control District

DATE: ____________________

CERTIFICATE OF AUTHORITY

I, ______________________________, do hereby certify that I am the Counsel for the Fresno Metropolitan Flood Control District, that the Fresno Metropolitan Flood Control District is a legally constituted public body with full authority and legal capability to perform the terms of the agreement between the United States of America and the Fresno Metropolitan Flood Control District, in connection with the Redbank and Fancher Creeks, California, Flood Control Project, and to pay damages, if necessary, in the event of the failure to perform, and that the persons who have executed the agreement on behalf of the Fresno Metropolitan Flood Control District, have acted within their statutory authority.

IN WITNESS WHEREOF, I have made and executed this Certificate this ________ day of ____________, A.D., 19__.

____
Counsel, Fresno Metropolitan Flood
Control District

REDBANK AND FANCHER CREEKS,
CALIFORNIA

APPENDIX D

LETTERS OF INTENT

AND

LETTERS OF SUPPORT

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT
SACRAMENTO, CALIFORNIA

APPENDIX D - LETTERS OF INTENT AND LETTERS OF SUPPORT

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FRESNO METROPOLITAN FLOOD CONTROL DISTRICT

October 9, 1985

COLONEL WAYNE J. SCHOLL
DISTRICT ENGINEER
Sacramento District
U.S. Army Corps of Engineers
650 Capitol Mall
Sacramento, California 95814-4794

Dear Colonel Scholl

LETTERS OF INTENT
REDBANK-FANCHER CREEKS FLOOD CONTROL PROJECT

The Board of Directors of the Fresno Metropolitan Flood Control District had, on January 18, 1977, October 20, 1978, and May 16, 1979, provided letters of intent to furnish the local assurances required with respect to the proposed flood control project. The District's letter of May 16, 1979 included not only assurances relating to the traditional federal cost-sharing procedures, but also included the District's willingness to participate in new cost-sharing proposals which were being considered at that time.

The purpose of this letter is to reconfirm the District's intention to provide the necessary assurances for the Redbank-Fancher Creeks Flood Control Project. In evidence of such intention, the Board of Directors of the District adopted Resolution No. 1198, which affirms its commitment in the subject project and endorses the recommendations set forth in the Citizens Project Advisory Committee Report. Those recommendations specifically address the potential need of the District as the local project sponsor to participate with the Federal Government in project financing. The report recommends as follows: "That the local project sponsor include within the estimate of the project's local cost obligation, any and all local or state cost share increases arising from proposed changes in the Federal cost-sharing regulations."

With reference to our prior letters of intent and to Sacramento District's letter of August 2, 1985, and to discussions regarding construction of the Redbank and Fancher Creeks, California project held on August 16, 1985, this letter constitutes a continued expression of intent of the District to cooperate with the Federal Government in initiating construction of the Redbank and Fancher Creeks, California project in Government Fiscal Year 1987.

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To facilitate construction and operation of the Redbank and Fancher Creeks project, the Fresno Metropolitan Flood Control District intends to provide all Lands, Easements, Rights-iof-way, and Relocations (LERRs) necessary for the project during the period of project construction as defined in the project Draft General Design Memorandum dated September 1985. The Fresno Metropolitan Flood Control District also intends to provide such funds as are necessary to meet the following non-Federal requirements for construction during the term of construction. In addition to providing the LERRs, the Fresno Metropolitan Flood Control District intends to make a cash contribution such that the total non-Federal share will be at least 25% of the total project cost or LERRs plus 5% of the total project cost, whichever is greater. It is also understood that the Flood Control District will bear the costs of operating and maintaining the project upon completion of construction in accordance with regulations prescribed by the Secretary of the Army.

The project to be constructed is that described in the Redbank and Fancher Creeks, California Draft General Design Memorandum dated September 1985 or said document as amended by Congressional action. Attached as Exhibit A is a schedule of non-Federal expenditures for the cash contribution portion of the non-Federal requirement through the construction period beginning in Government Fiscal Year 1987 and ending in Government Fiscal Year 1990. The schedule is based on a $74,200,000 estimate of total project cost, which includes an allowance for inflation through the construction period. It is understood that estimates of costs are preliminary and that final costs will depend on the actual costs of construction.

The Fresno Metropolitan Flood Control District is the agency empowered by law to provide the non-Federal cooperation required for the Redbank and Fancher Creeks project. Prior to construction, the District intends to enter into a binding written agreement with appropriate representatives of the United States Government which address project construction and satisfies the requirements of Section 221 of Public Law 91-611. Attached as Exhibit B is an assessment of the Fresno Metropolitan Flood Control District's ability to pay the non-Federal portion of the project cost.

It is further understood that if this letter of assurance is acceptable to the ASA(CW), he will recommend to the Office of Management and Budget that an appropriate request for funds to support construction of the Redbank and Fancher Creeks project be included in the President's budget for Fiscal Year 1987. As previously recognized, if legislation is enacted which changes local cost-sharing and financing requirements for the Redbank and Fancher Creeks project, such cost-sharing and financing provisions will supersede this financial agreement.

Very truly yours,

Doug Harrison

DOUG HARRISON
GENERAL MANAGER-SECRETARY

Attachments

EXHIBIT "A"

REDBANK AND FANCHER CREEKS PROJECT

NON-FEDERAL CASH CONTRIBUTIONS

Government Fiscal Year		Amount ($1,000)
1987		$ 0*
1988		0*
1989		4,700
1990		900
	Total	$ 5,600

*Value of Lands, Easements, Rights-of-way, and Relocations furnished will exceed 25% of yearly project costs.

Note: Total non-Federal share of project cost is currently estimated to be $18,500,000 (Cash-5,600,000; LERR-$12,900,000); based on a total project cost, inflated through the construction period, of $74,200,000.

EXHIBIT "B"

REDBANK AND FANCHER CREEKS PROJECT
ASSESSMENT OF FRESNO METROPOLITAN FLOOD CONTROL DISTRICT

The District is authorized by statute to enter and be legally bound under a cooperative agreement. It is clear from Section 73-8 of the State Water Code that the District is possessed of a substantial range of powers to fulfill its functions. The District is expressly authorized to contract with the Government and to do any acts necessary or proper to perform the terms of the agreement. The District can sue and be sued which indicates it can hold and save the Government harmless. There is authorization for the District to acquire property of any kind and to use eminent domain powers to acquire it if necessary.

The District has authority to obtain revenue for its functions from four sources: (1) property assessments; (2) borrowing; (3) levy of fees for services; and, (4) issuance of bonds. All income must, of course, be utilized only for proper District purposes. Borrowing and issuance of bonds do, however, have restrictions and conditions.

Borrowing by the District under Code Section 73-14(a) can be for ordinary expenses. Under Code Section 73-14(b), the District can borrow from the State and Federal Governments for improvements required as a result of declared emergencies or to meet local performance requirements for State or Federal flood control projects. There is no definition of ordinary expenses nor is it clear whether these sections modify or restrict the authorization in Code Section 73-8 (8) to incur indebtedness. Section 14 limits the amount of indebtedness to an "amount which could be raised by a ten cent ($0.10) tax levy upon all taxable real property which is subject to such levy in the district as shown by the last equalized assessment roll." Thus, there is a limit or may be a limit on the amount of funds the District could borrow if needed to participate in a project. Also, pursuant to Articles 13A and 13B of the California Constitution, general obligation bond issues are now unavailable to the District.

Attachment

It is apparent from all information available that the District is possessed of sufficient statutory authority to enter, be bound, and perform the terms of a local cooperation agreement. It is also apparent that local revenue authorities are limited by State law and the California Constitution.

BY: ______________________

Attorneys for
Fresno Metropolitan
Flood Control District

FRESNO METROPOLITAN FLOOD CONTROL DISTRICT

September 24, 1985

LT. GENERAL E.R. HEIBERG, III
Chief of Engineers
Department of The Army
Washington, D.C. 20314-1000

Dear General Heiberg

REDBANK-FANCHER CREEKS FLOOD CONTROL PROJECT - CALIFORNIA

We are pleased to announce that the California State Legislature, at the close of its 1985 session, enacted legislation authorizing State participation in the subject project. Pursuant to the California Water Code, such authorization effects the committment of the State to fund up to 75% of the lands, easements, and rights-of-way and 90% of the required relocations, this in partnership with the local sponsor. Such action by the State represents an assignment of the State's priority to the project and its endorsement for the general plan of improvement submitted to the Congress.

Upon execution by the Governor, the legislation will permit State funds to be expended for project rights-of-way. Acquisitions have, in fact, already begun through funding advances by the local sponsor. Such right-of-way acquisitions are being pursued in anticipation of timely action by the Congress toward project construction authorization. We have made every effort to insure that this authorization is included in the omnibus bills currently before the Congress. Should such authorization fail, we will request that the Corps, the Administration, and the Congress consider special authorization much like that provided through the appropriations process during the 1985 Congressional session.

We wish to take this opportunity to express our appreciation for the outstanding efforts on our behalf by the staff of the

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Sacramento District and by members of your Washington staff. At each level, they have been ready and effective in their assistance.

Very truly yours

Doug Harrison

DOUG HARRISON
GENERAL MANAGER-SECRETARY

c: Colonel Wayne J Scholl, Mr. John Mack, U.S. Army Corps of Engineers
Congressman Coelho
Congressman Lehman
Congressman Pashayan
Senator Wilson
Senator Cranston

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Division of Ecological Services
2800 Cottage Way, Rm. E-1803
Sacramento, California 95825

October 9, 1985

District Engineer
Sacramento District, Corps of Engineers
650 Capitol Mall
Sacramento, California 95814

Subject: CE - Redbank and Fancher Creeks, California - Draft General Design Memorandum

Dear Sir:

We have reviewed the September 1985 draft General Design Memorandum and provide the following comments.

If the permanent recreation pool in Big Dry Creek Reservoir is deleted from the project, there will no longer be a need to plant 35 acres of riparian vegetation as indicated in our 1976 Fish and Wildlife Coordination Act report and the conceptual planting plan provided on August 15, 1984. Furthermore, without the permanent recreation pool, neither a reservoir fishery nor angler-use benefits will occur.

However, there still will be a loss of about 120 acres of grassland and agricultural land due to the construction of the detention dams (page 26 of the Corps' final EIS, July 1, 1980). This should be included in Table 27.

We appreciate the opportunity to provide comments on the Draft General Design Memorandum. For assistance, please contact Wally Wiest at 978-4613.

Sincerely,

James J. McKevitt
Field Supervisor

cc: RD (AHR), FWS, Portland, OR

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The enclosed documents from USACE Sacramento District are hereby submitted for inclusion in DTIC's technical reports database. The following is a list of documents included in this shipment:

ADB344304 • Lemon Reservoir Florida River, Colorado. Report on reservoir regulation for flood control, July 1974

ADB344333 • Reconnaissance report Sacramento Metropolitan Area, California, February 1989

ADB344346 • New Hogan Dam and Lake, Calaveras River, California. Water Control Manual Appendix III to Master Water Control Manual San Joaquin River Basin, California, July 1983

ADB344307 • Special Flood Hazard Study Nephi, Utah, November 1998 (cataloged)

ADB344344 • Special Study on the Lower American River, California, Prepared for US Bureau of Reclamation – Mid Pacific Region and California Dept. of Water Resources..., March 1987

ADB344313 Transcript of public meeting Caliente Creek stream group investigation, California, held by, the Kern County Water Agency in Lamont, California, 9 July 1979

ADB344302 • Initial appraisal Sacramento River Flood control project (Glenn-Colusa), California, 10 February 1989

ADB344485 • Report on November-December 1950 floods Sacramento-San Joaquin river basins, California and Truckee, Carson, and Walker rivers, California and Nevada, March 1951

ADB344268 • Reexamination Little Dell Lake, Utah, February 1984

ADB344197 • Special report fish and wildlife plan Sacramento River bank protection project, California, first phase, July 1979

ADB344264 • Programmatic environmental impact statement/environmental impact report Sacramento River flood control system evaluation, phases II-V, May 1992

ADB344201 • Hydrology office report Kern river, California, January 1979

ADB344198 • Kern River – California aqueduct intertie, Kern county, California, environmental statement, February 1974

ADB344213 • Sacramento river Chico Landing to Red Bluff, California, bank protection project, final environmental statement, January 1975

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ADB344261 • Sacramento river flood control project Colusa Trough Drainage Canal, California, office report, March 1993

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ADB344267 • Sacramento River Flood Control Project, California, Right Bank Yolo Bypass and Left Bank Cache Slough near Junction Yolo Bypass and Cache Slough, Levee construction, General Design, Supplement No. 1 to Design Memorandum #13, May 1986

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